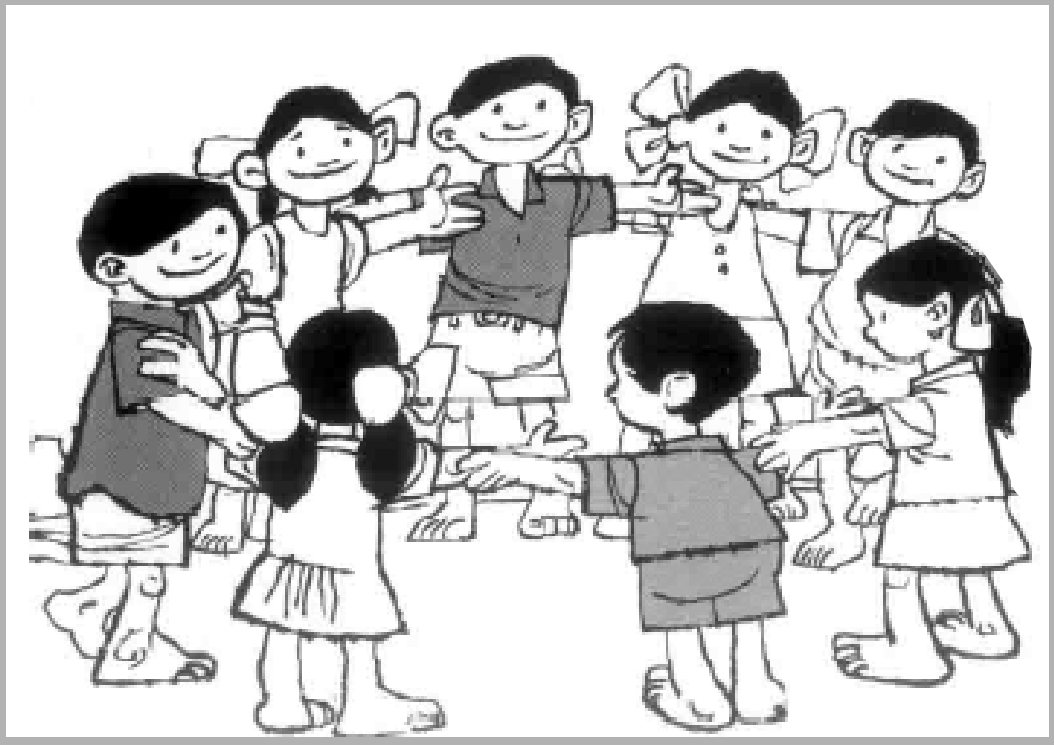
Basics of Astronomy through Role play



Handbook for science activists and teachers

T V Venkateswaran
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BASICS OF ASTRONOMY THROUGH ROLE PLAY

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Foreword

This handbook on using role play to communicate basics of astronomy to young children is inspired by Mr Samar Bagchi, who used the technique with great efficacy to explain astronomical concepts not only to children but also adults. His enthusiastic and lively sessions made such a lasting impression that we still fondly remember them even after many years ; for the joy and the aha! experience of acting and visualizing movements of heavenly bodies, and unraveling their mystery, as they silently course above us every single day of our lives.

This handbook draws upon some of the activities developed under the UNAWE (Universe Awareness) project of IAU (International Astronomical Union) for the International Year of Astronomy—2009. Often the projects and activities carried out under the aegis of International Years hardly reach or address small children. Nevertheless, children are the future; and UNAWE was launched with participation of many countries and organizations to specifically develop programmes and undertake activities to reach young children. One of us who had the opportunity to participate in a international material development workshop was immensely benefited from the refreshing ideas and novel strategies suggested by the participants from across the world.

In this compilation we have been helped and motivated by many. We thank all our colleagues in All India Peoples Science Network, Bharat Gyan Vigyan Samithi, Digantar and Vigyan Prasar for the encouragement. We thank children of Diganthar school, Teachers from SSA, Chattisgarh, Para teachers of CHIRAG, Uttarakand, who helped us with enthusiastic participation and queries while we developed these activities.

We do earnestly hope that this handbook will be of use to teachers and science activists to inspire and motivate young children.

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GOALS:

- Understand how various parts of earth experience different times according to position with respect to sun.
- How celestial objects rise and set at the horizon
- understand why we see different phases of the Moon
- understand why moon rises every day late by about 50 mts
- understand how we see only one face of moon from the Earth
- Understand how the Earth goes around Sun; even while rotating. What is one year?
- Understand that at different position in the earth's orbit, different part of the stellar sphere would be visible
- Understanding ecliptic and its relation to sun, earth and stars
- Position of pole star
- Tilt of the axis of Earth and its effect (seasons, length of the day and night)
- Apparent motion of stars
- understand the direction of rotation (anti-clockwise) of most solar system objects
- Understand definition of constellation and zodiac signs

What is role play?

Role play is a Teaching learning technique wherein the children take the role of someone or some object. They act out activities of the person in question or the object being studied. In the process of acting out understanding of the inner working is made clear. The role play is NOT a scripted drama. The facilitator/ teacher should NOT direct how the children should play, but guide them by helping them in taking positions/ roles; however adequate time should be given for the children themselves to figure out their roles.

To START:
Three people from the class/ group are selected to play roles of the Sun, Earth and Moon. (For certain activities we may need more children to take part as Rashis)

Earth person: Your head represents planet Earth and your nose is an imaginary person on the Earth's surface. Remember: Just as a real person standing on the surface of the Earth, your nose can't see what's happening behind your head, on the other side of the "Earth." However, there are others people on the other side of earth who may see different view of the space.

Other children who are not part of the role play: These people stand a few feet away. Because they are viewing the Earth and Moon from a larger distance, they should see the "big picture" of what's happening.

Do the following sections in order. They build on each other conceptually. As you proceed, be sure to learn and understand the vocabulary words in bold italics.

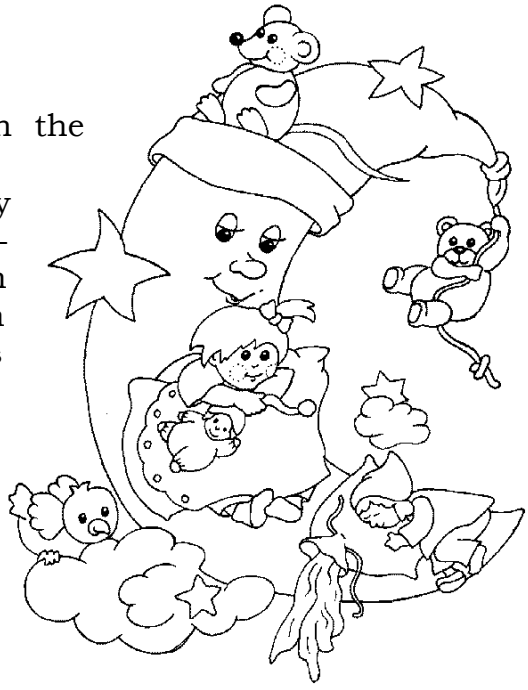
Activity 1
Preparatory activity- noting the changes in the moon

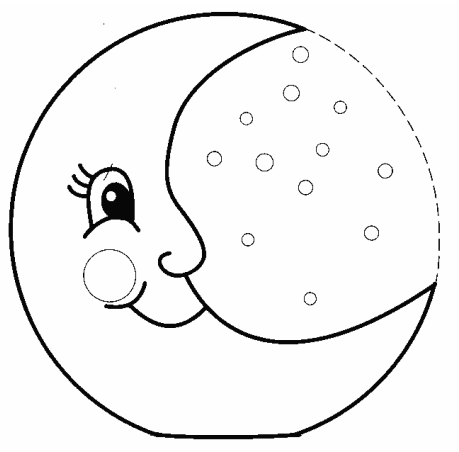
Exercise 1.1: Observing the moon for at least over a month and noting its shape

Ask the children to observe the moon for a month or longer. Ask them to note the shape in the activity sheet. After few days ask them to notice the dark and light patches on the face of moon. Ask them to observe it as well as its phases. Point out that moon may at times be visible in the morning. There may be gaps in observations, but at this point they need not be corrected. Collect the sheets from the children and discuss how the shape of moon waxes and wanes. By now some would have noticed that the shape of the dark and light patches do not change and appear to be a permanent feature on the face of moon. Recall the story about the Rabbit on the moon. Emphasis that we from Earth see only one face of the moon. Further stress that the face seen from Earth is same all over the world… that is, it is same face that we see from India as well as America.

Lead them to questions:-

- Why we see lunation on the moon?
- Do we see moon in the day time? The general statement that Sun comes in the morning and Moon comes in the evening is not correct





Worksheet for children

Charting the Moon

Name: _____

Month: _____

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday

Activity 2
Day and night.

This activity has only Sun and Earth persons. Let the moon person take rest.

The Earth person's head represents the globe of the Earth. Notice that half of the Earth (one “hemisphere”) always experiences daytime while the other hemisphere sees night.

Let the Earth rotate to the left (i.e. counter clockwise) so that Mr. Nose faces directly towards the Sun. In this position it's noontime for Mr. Nose and midnight for someone on the opposite side of the Earth let us say ‘Mr. Back’. Locate Mr. Nose's horizons to the east and west. To ease understanding, the earth person may fold her arms in such a way that her elbows become the East and West. The elbows are actually the limits of the visual field of Mr. Nose. S/he will see only whatever is visible up to the elbow, nothing beyond (behind).

Point out the actual horizons and explain ‘what is meant by ‘above’ and ‘below’ horizon, & how we are showing it as in front of or behind the elbow. In our role play, objects at the elbow will be seen just at the horizon.

To fix which elbow is eastern horizon & which is western, make the earth person rotate in anti-clock wise direction. As soon as the sun goes behind an elbow, or ‘sets’, this elbow becomes the western horizon. This will turn out to be the right elbow. Similarly, as soon as a celestial object comes in front of an elbow or ‘rises’, it become the eastern horizon. You will find that this is the left elbow.

1. Make a student stand in the middle representing Earth.
2. The Earth stands little away from Sun. Make him/her fold the arms such that her right elbow becomes the western horizon.
3. Inform that all the children in the class room are at the tip of the nose. That is the city/ village where the activity is tak-

ing place. We are all lying down and seeing the sky from the tip of the nose. Let the facilitator lie down this way & show to the viewer.

4. The Earth has to rotate counter- clockwise as seen from above the north pole. So the child has to also rotate counter - clock wise – to represent daily rotation of Earth.
5. Now the Earth- child rotate. As she faces the sun, it is 12:00 noon at the nose; as she turns away and her right elbow is faced towards the sun it is evening 6 pm. As her back is towards the sun it is night 12:00 pm and when her left elbow is towards sun it is morning 6 am. All this refers to time at the Nose.
6. Repeat this rotation few times; till all the children are familiar with the idea and are able to guess the time from the way Earth-girl is oriented. That is, by looking at the way the right and left elbows are positioned with respect to the Sun the children should be able to guess the time (not 5:54 like accuracy, but morning around 6 am; evening around 4 pm etc)
7. Ask the Earth girl to take various positions and ask the children to make a guess of time (at the nose of the Earth girl)

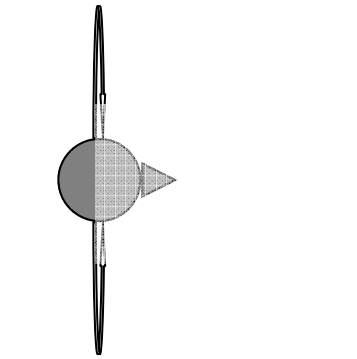
Exercise 2.1: What time of day (sunrise, noon, sunset, midnight) would it be 1. or the left ear and 2. or the right ear?

Rotate the Earth (to the left) so Mr. Nose experiences these times: Sunrise, noon, sunset, midnight.

Exercise 2.2 For each of these times for Mr. Nose, what are the corresponding times for an imaginary person on the back of your head? Fill in the blanks in the following table.

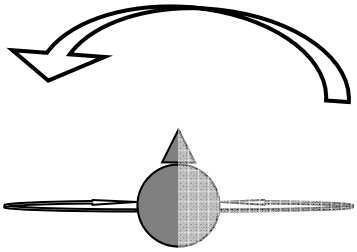
Time for Mr. Nose	Time for Mr. Back
Sunrise	
Noon	
Sunset	
Midnight	

By end of these activities all the children should be familiar with the role play and orientations.



NOTE: Some illustrations of role play positions.

In the shown arrangement the time at the 'nose' is noon (12:00) hrs. The earth person's right hand is western horizon and left hand is eastern horizon as he/she rotate in anti-clockwise direction.



As the Earth person rotate in anti-clockwise direction, in the above orientation, it is evening /dusk for Mr. Nose. Sun is at the western horizon.

Activity 3
Phases of moon.

Now ask the moon person to take part. Draw a circle around Earth, to represent the moon's orbit around Earth (not absolutely essential but would help).

Make clear that the moon has no self illumination and what we see is through reflected sun light. Also, the moon moves around Earth in an anti-clockwise direction, which is also the same direction at which Earth rotates as well as revolves.

Exercise 3.1 Which part of moon is illuminated and which side is dark.

- Make the Earth person stationary. Fix the sun person or direction of sunlight.
- Now make the moon go around in its orbit. To begin with, let the moon be between Earth and Sun. Ask the children to guess which part of the moon's head would be illuminated, which part of the moon would be dark due to absence of sun light.
- Now make the moon take a position such that moon-earth–sun become aligned. Now ask the children to discuss which part of the moon is illuminated, which part is not.
- Now make the moon take position in various position in its path. Let children guess which part of the moon is illuminated and which part is not.

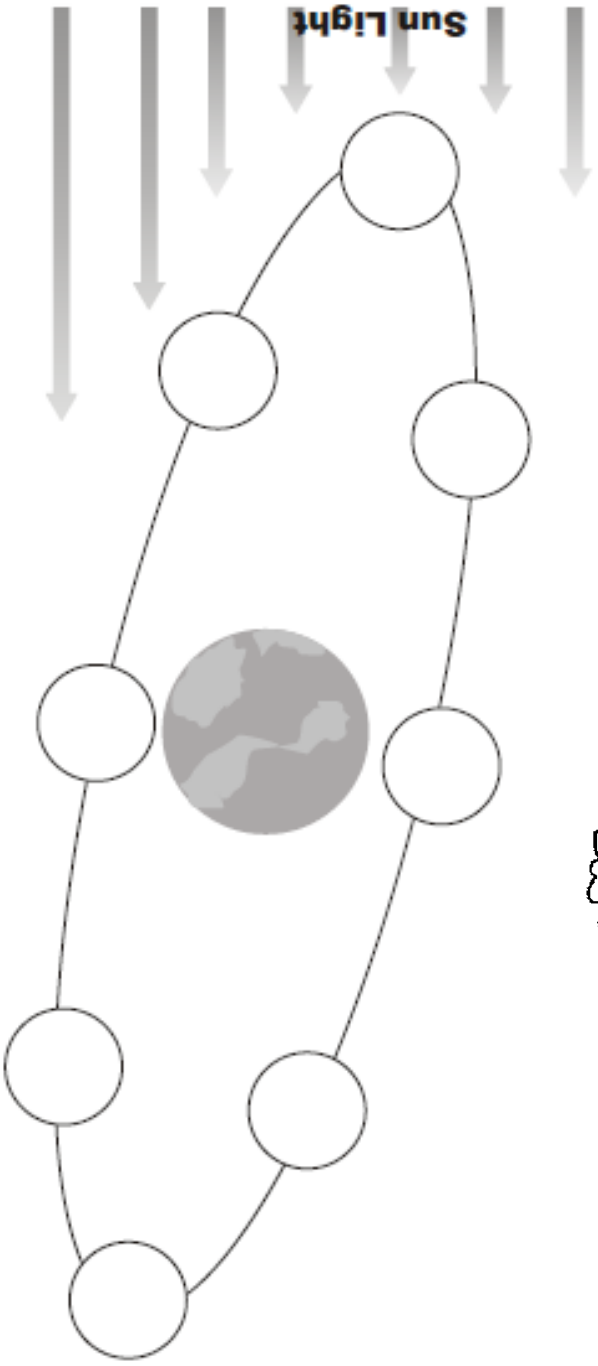
Repeat these exercises many times so that everyone is clear about moon's illuminated and dark part at its various locations.

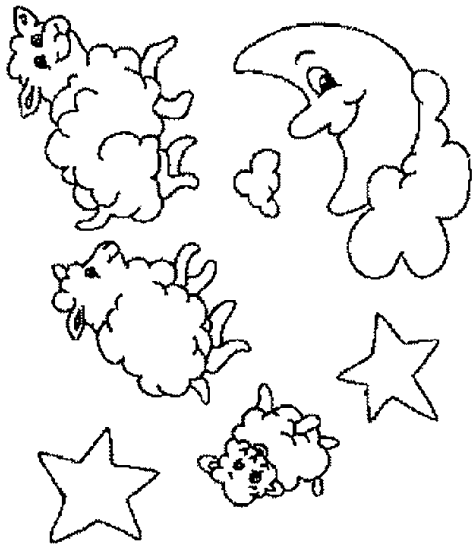
Exercise 3.2 Sheet where the children have to shade the dark position of moon.

The sheet is given on page number 14.

Moon sheet

Mark which part of the moon will be dark and which illuminated. Shade the dark region.





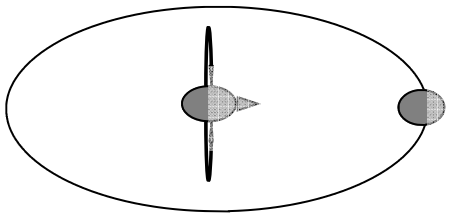
Exercise 3.3 When will the moon be Poornima (full moon) and when it will be amavasya (new moon)?

Let the Earth, Sun and moon take position. As an exercise, let the class children guide where the moon should be positioned to make the moon full moon (or new moon) for a person at the nose. Then ask where the moon should be so that it is full moon for a person at the back of the head.

What is important in this exercise is the orientation of the Moon. What needs to be made clear is that irrespective of where the nose is facing, if it is full moon, it is full moon! That is moon has to be oriented with respect to the Sun in a particular way. As the Earth rotates each and every part of the Earth will experience full moon on that day!

Initially practice this for only full moon and new moon. Do not rush with all the phases of moon (called *kala* in Hindi).

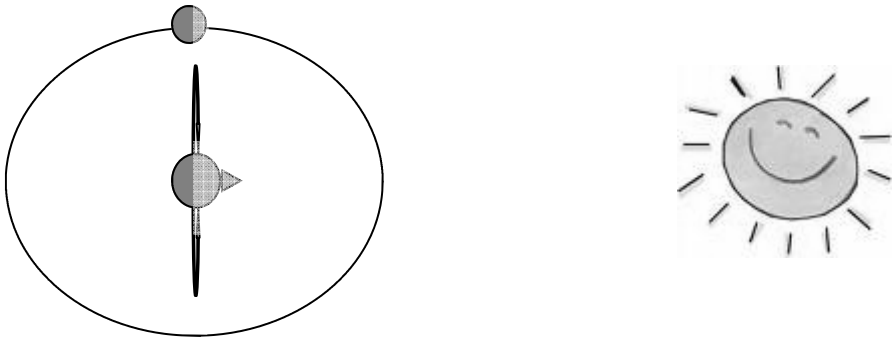
CAUTION: Someone who is intelligent or knowing a little bit more will say that when Moon is between Earth and Sun it is eclipse time. You can avoid such a situation by choosing two children who have different height. So you can say that though moon is in same direction of sun it is not exactly in the straight line. Also tell the class that you will discuss why then eclipses occurs later with a separate model/picture.



In the above arrangement one can see that the moon is in the same direction as the Sun. The Sunlit portion of the moon will be facing away from Earth. Earth facing side of moon will be dark due to absence of sunlight. Therefore in this alignment we will have new moon.

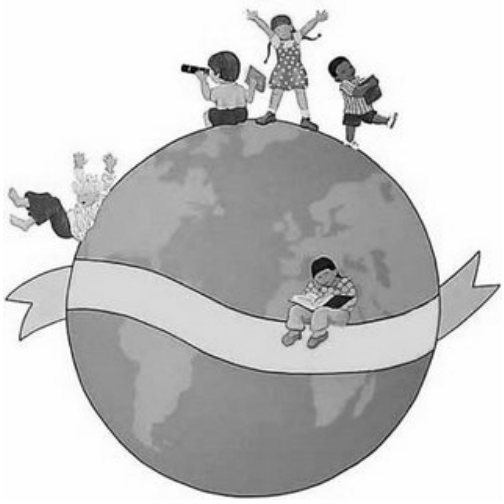
Exercise 3.4 Where should be moon to be half moon?

Like the earlier exercise, ask the children to guess where the moon would be half. You will find that being 90 degree away- at two positions moon will be half moon. Notice that this time also for everyone on the surface of earth it is half moon. Also point out the opposing half lit faces in these two positions depending on the direction of sunlight.



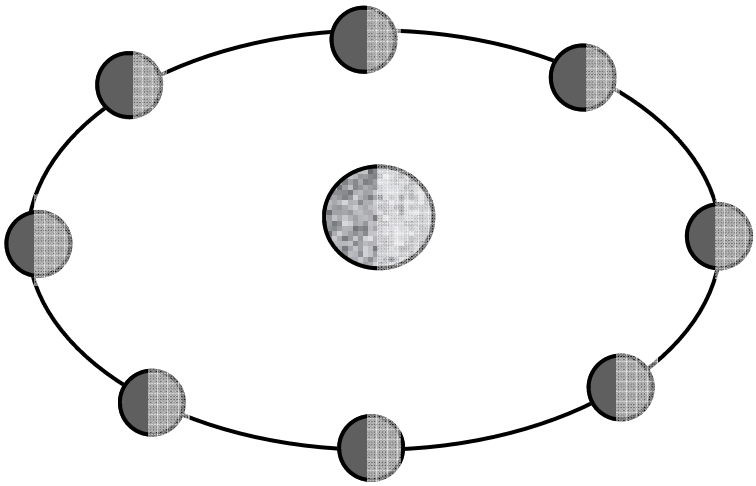
Exercise 3.5 : Waxing and waning of moon

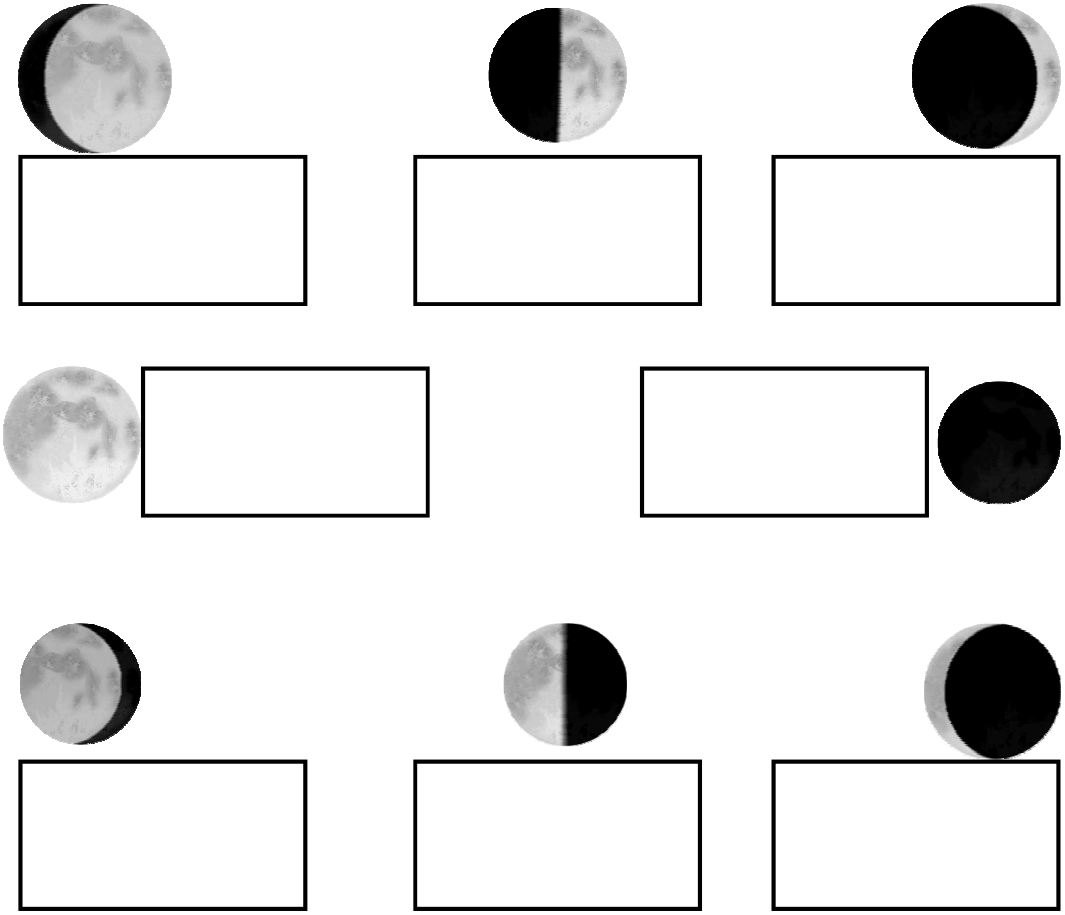
Ask the children to guess, in which half of the moon's motion it would be waxing and in which waning. Explain by role play. Notice that when the moon is going from full moon to new moon it is waning and new moon to full moon, it is waxing (Krishna paksha and Shukla paksha)



Exercise 3.6: Worksheet to identify the phases of the moon

Use the following worksheet and ask the children to identify the phases of the moon





Exercise 3.7: When will full moon rise; when will half moon rise

Let the Moon person take positions. Let the Earth person rotate about its axis. See when the moon is on the Eastern horizon of Mr Nose. Also observe the time of setting of full moon, new moon and half moon position.

Make a table for this. Place the moon in four different positions (phases) with respect to Earth. Now each time the earth person makes a full rotation. The children may be asked to spell out the time of the moon rise and moon set for each of the phases. Fill up the following table:-

Phases	**Rising time**	**Setting time**
Full moon		
New Moon		
Half (Krishna Paksha)		
Half (Sukla Paksha)		

During this activity the facilitator must highlight certain observations:-

1) The Moon rises or sets at different times in the day also
2) Moon will be visible even during the day time in many situations (which is corroborated by the actual observations)

Exercise 3.8: Why does the moon rise ~50 minutes later each day?

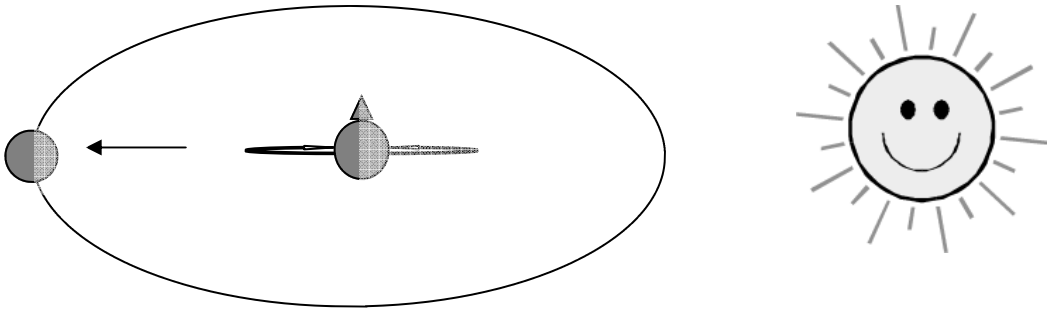
1. Place Earth, moon and Sun in such a way that Sun is at the right elbow and moon is at the left elbow.
2. Now the time is evening 6 pm. Sun is setting; moon is rising.

3. Ask the Earth person to rotate a bit and show how sun will set below western horizon and moon will come up the eastern horizon.
4. Now let the Earth person make one complete rotation and come to the earlier position… that is next day evening 6 pm.
5. Now where will be the moon at this time?
6. We know the Moon also goes around Earth. It goes around earth approximately once in 30 days (no need for more precise 29.5 days or 27.3 sidereal period at this juncture, we must keep it simple).
7. So moon should move 12 degrees (360 degree / 30 days), that is moon should have moved a little bit **anti clock wise**.
8. Make the moon kid to move a bit anti-clockwise.
9. Now it is next day (Day 2), 6 pm. Sun is at the western horizon like yesterday. However, moon is not at the eastern horizon! It has moved a bit in its orbit.

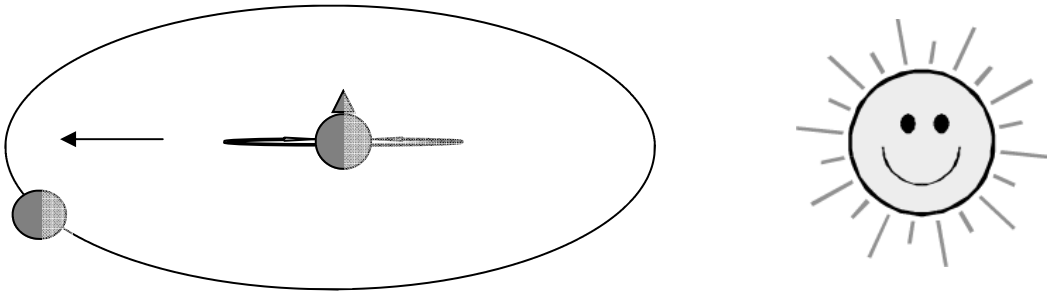
So now observer at the nose of the Earth- person has to rotate a bit more before it can see the moon appear at the left elbow. For the earth to come to the same position as before where Moon is rising at eastern horizon, it will have to rotate 12^0 extra. The time taken will have to rotate about 48 minutes. Why? Earth takes 24 hrs (or 1440 minutes) to make a rotation of 360^0. So for 12^0 it works out to 48 minutes.

NOTE

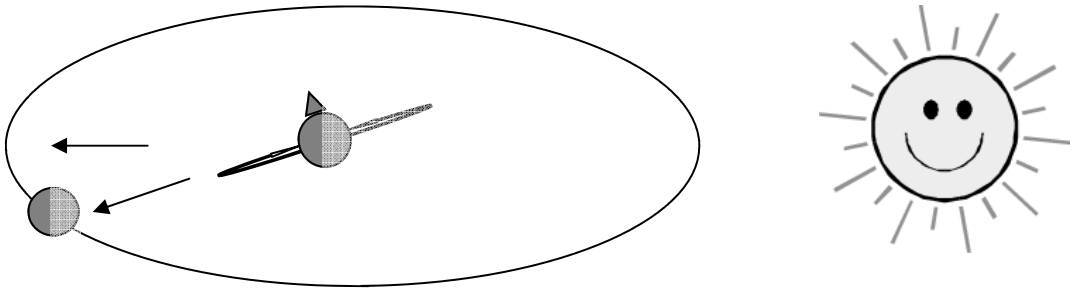
Here we have taken the time of movement of moon as 30 days for a full revolution around the earth. This is a rough estimate. Normally for moon to come back to the same position on its orbit, the time taken is 27.3 days (sidereal month). In these 27.3 days, the earth moves ahead in its orbit around the Sun. The Moon has to travel some extra distance to come from an amavsya position, back to another amavsya position, which takes 29.5 days. Hence the average delay time of rising is roughly 50 minutes, instead of 48 minutes as shown above.



Evening 6 pm position. Sun is setting and moon is rising.



Next day same time; evening 6 pm. Sun is setting but moon is 12 degrees below horizon.

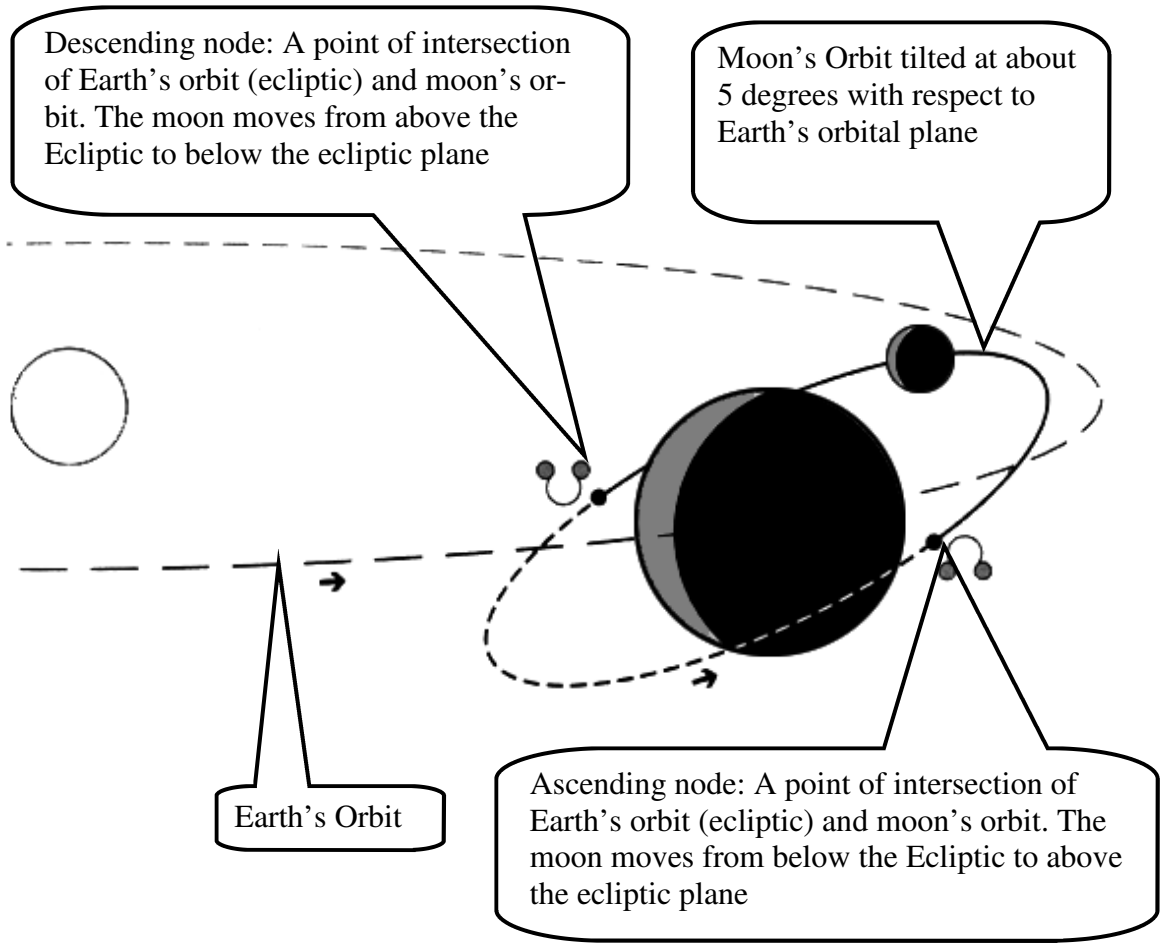


Earth will have to make additional rotation of 12 degrees to catch up with the moon… that is moon will be at the eastern horizon only after about 50 mts.

Why eclipse do not occur on every new moon & full moon day?

If we keep the earth's orbit and moon's orbit in the same plane, every new moon or full moon position becomes an eclipse position. We know that eclipse happens when Sun, Moon and Earth come in the same straight line. In a full moon situation, the moon comes between Sun and Earth and therefore there is a possibility of solar eclipse (moon obstructing the sun). In a new moon situation, the earth comes in between sun and moon and a possibility of lunar eclipses occurs because earth obstructs light reaching the moon.

But we know that in each of these position eclipses do not happen. This is because the moon's orbit is tilted to the Earth's at about 5^0. We can show the earth's orbit with a wire ring in which a small ball is threaded through to show the Earth. A small ring



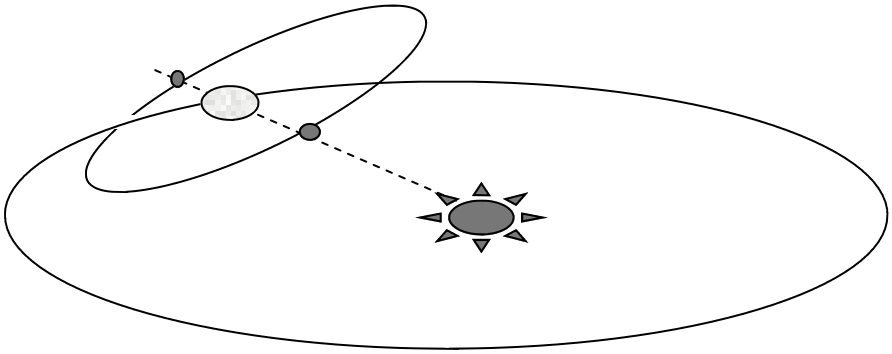
with a small bead (like bangle with a bead of knotted thread tied to it) can show the moon's orbit; and moon's position.

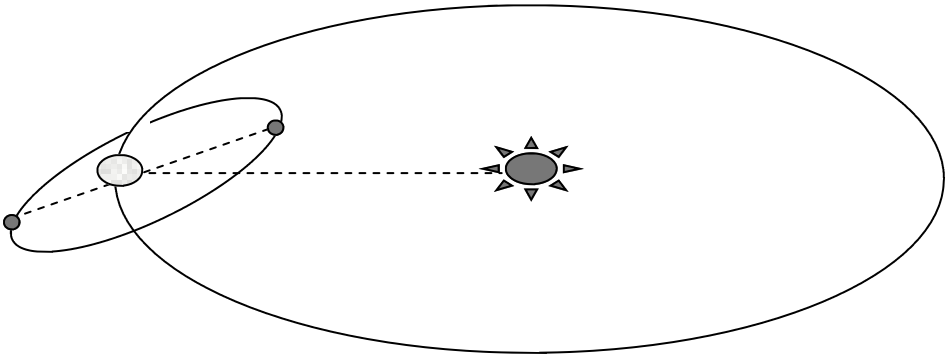
When we tilt the moon's orbit in two extreme positions of Earth's orbit, it can be shown that in spite of full/new moon position, the three bodies (Sun, Moon and Earth) do not come in a straight line.

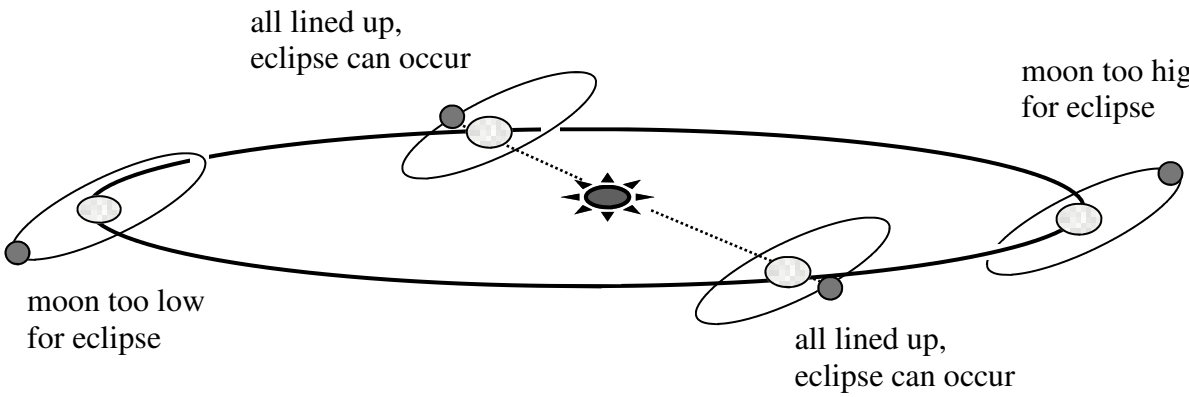
Whereas, at 90^0 to these positions, keeping the tilt same, moon comes in two full/ new moon positions where straight line alignment indeed becomes possible. Explain that these two points in the sky where the moon's arrival means either kind of eclipse are called Rahu and Ketu in Indian astronomy.

Total Solar eclipse

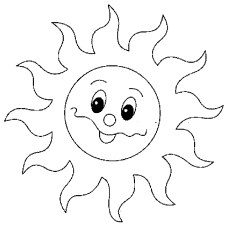
Total lunar eclipse

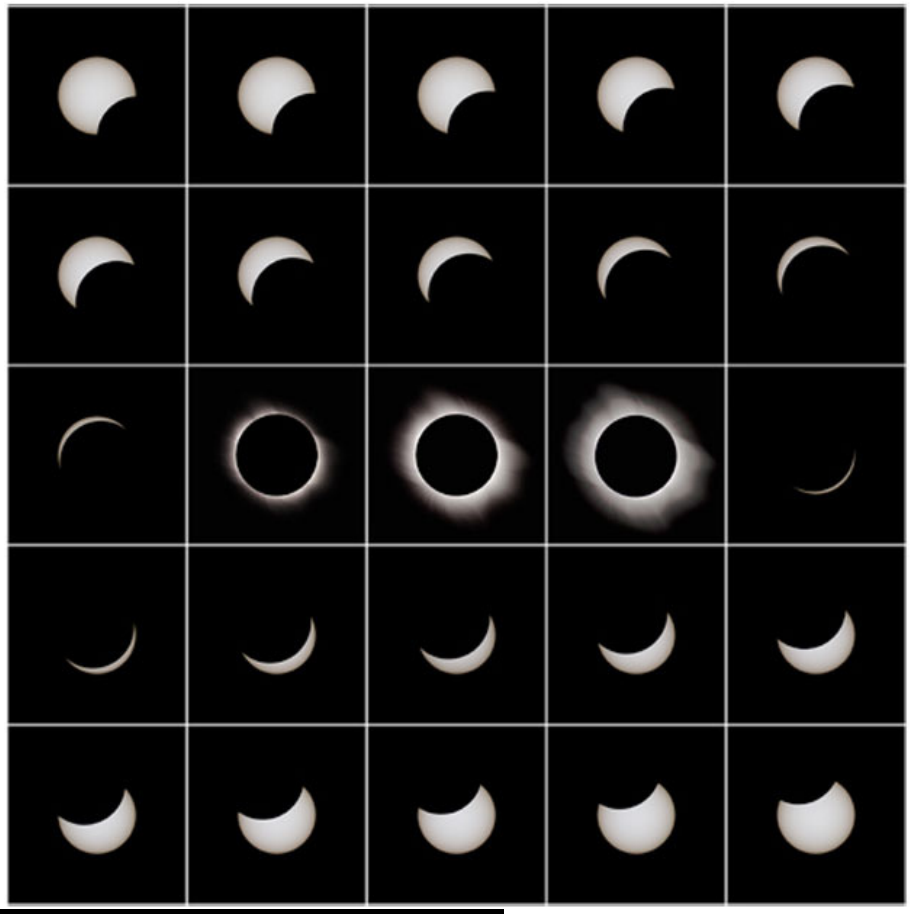


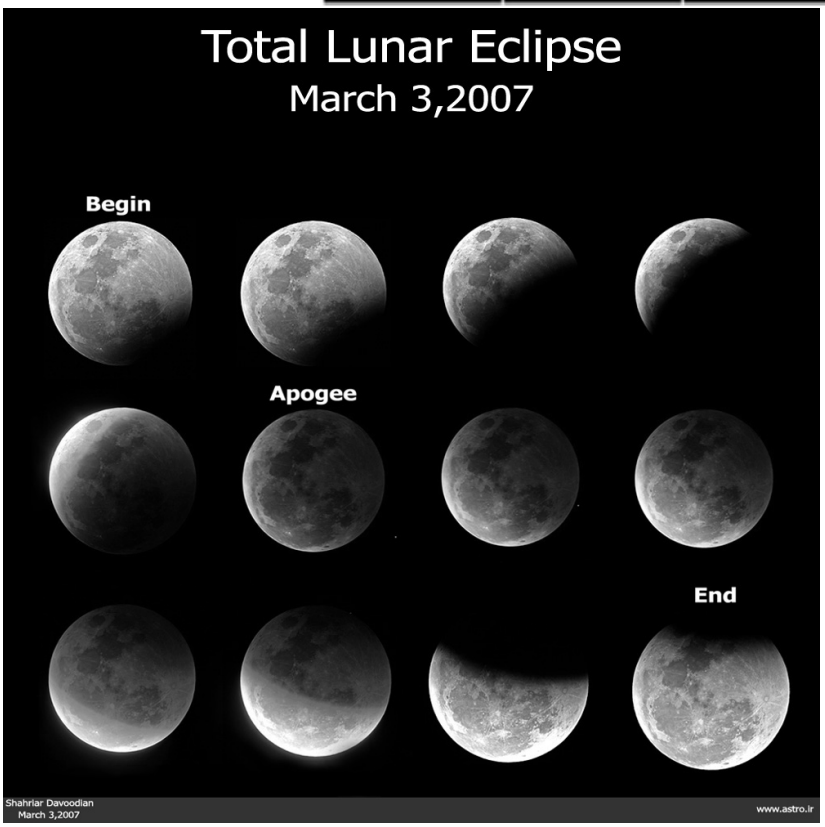



all lined up,
eclipse can occur
moon too high
for eclipse
moon too low
for eclipse
all lined up,
eclipse can occur

Total Solar Eclipse







Total Lunar Eclipse

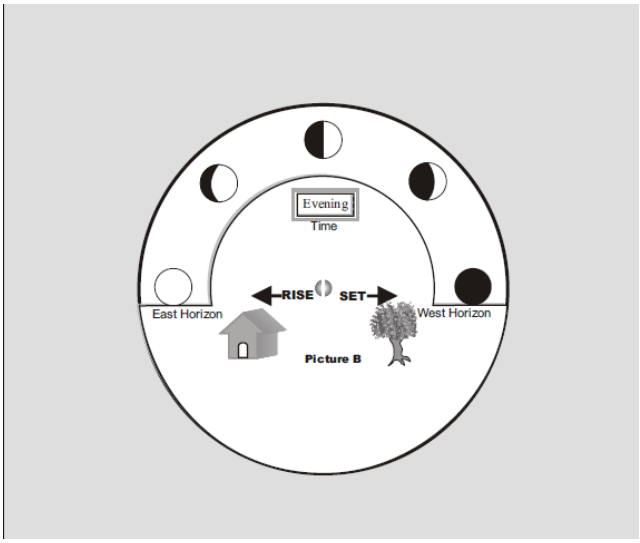
How to Make a Moon Dial

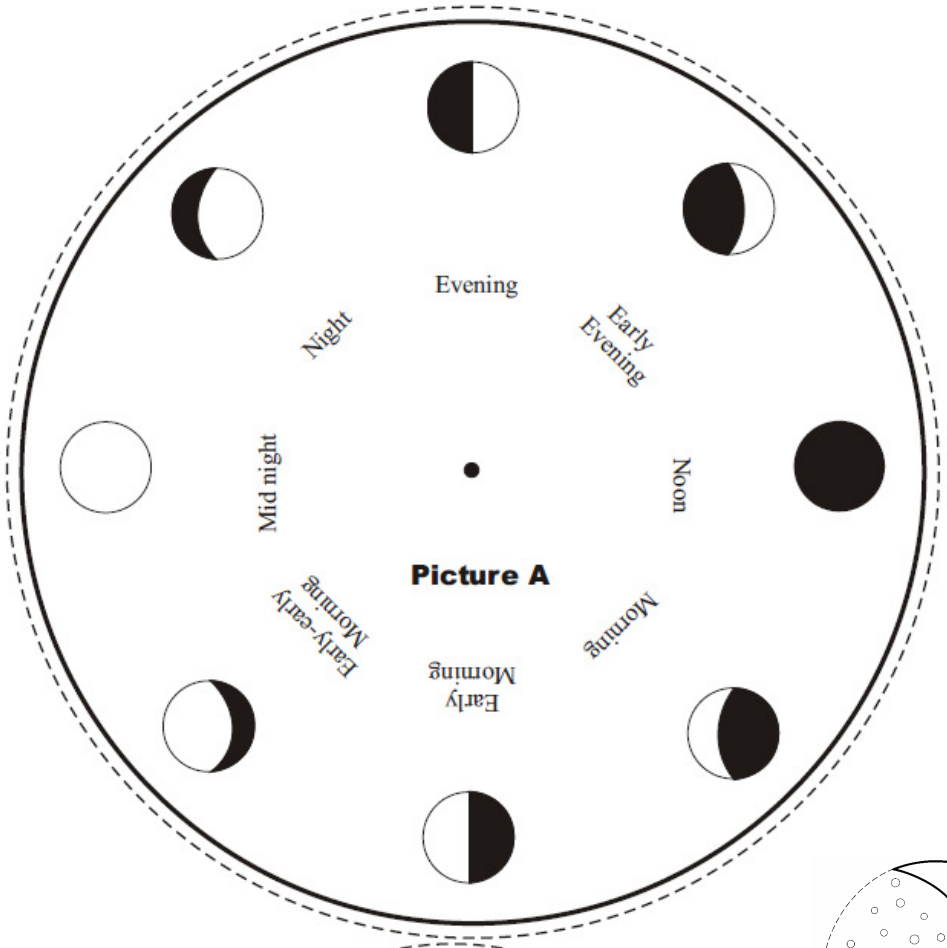
When will you see what phase of moon? Would you be able to see first quarter in the early morning sky? Would you be able to see third crescent in the western sky?

The Moon dial will help you understand the rising and setting time of moon's 8 distinct phases.

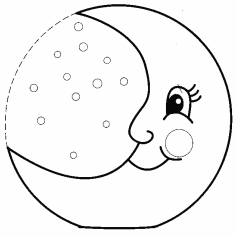
Procedure :

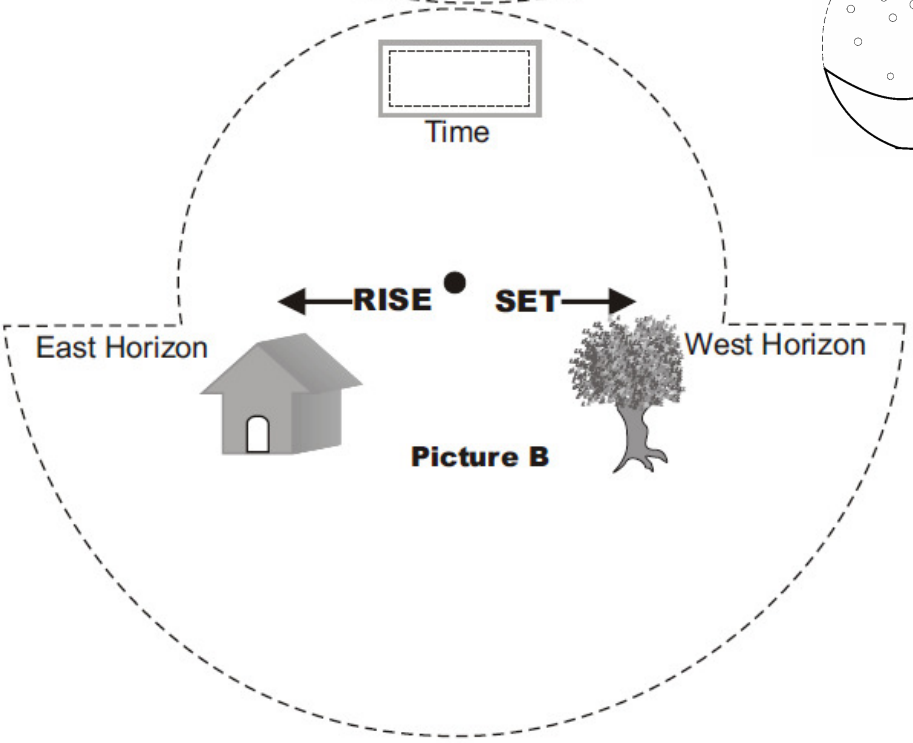
1. Paste the given datasheet on thick drawing sheet for making the moon dial.
2. Cut picture A & B along the dotted lines.
3. Make a window by cutting along the dotted line in the 'time' box in Picture B
4. Place B above A. Place them one above the another so that the centers match. Use a pin to fix them together so that one would be able to rotate the two.
5. Your Moon dial is ready . Hold your moon clock so that the direction finder portion has the words horizon right side up, or make sure the house and tree are upright. This portion of the moon clock represents the ground at your feet.
6. To know the rising time of a given phase, rotate the dial so that the particular phase is in the Eastern Horizon. The time shown in the window indicates the rising time of that phase. To know the setting time, align the desired phase with western horizon. The time shown in the window indicates the setting time for that phase.





Picture A





Picture B

Near Side of the Moon

Activity 4
Why moon shows only one face to Earth

Exercise 4.1: Stories about the Rabbit on the moon's surface

Start this session by narrating the following story:

Look up at the moon. What do you see? Some areas are dark; some bright. There are number of tales about what is seen on the face of the Moon.

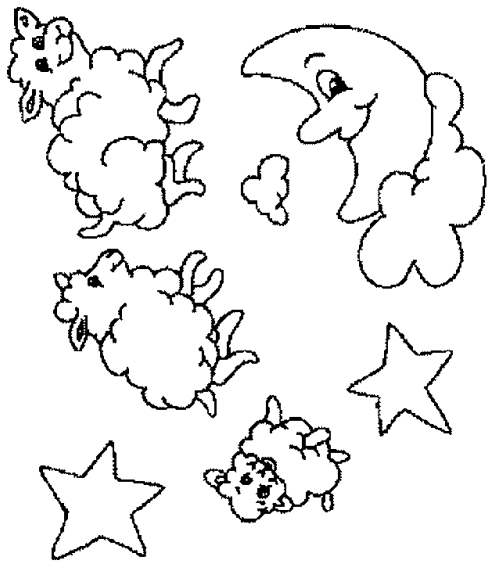
In the Buddhist folklore – Jataka tales, a monkey, an otter, a jackal, and a rabbit resolved to practice charity on the Upavaas (Uposatha) days. According to Buddhist practice, Upavaas is a monthly period when one is supposed to be on vrat (not eating anything) and practice charity. The four animals resolved to observe Upavaas believing that demonstration of virtue would earn them a great reward in their afterlife. An old man came begging on an Upavaas day. It was a cold day and as he was tired, he build a fire and rested there. The four animals decided to provide him with his needs. The monkey gathered fruits from the trees and the otter collected dead fish from the river bank, while the jackal wrongfully pilfered a lizard and a pot of milk-curd. The rabbit, alas, knew only how to gather grass. The old man could not eat grass. Its helplessness made the rabbit sad. Suddenly it had an idea. The Rabbit offered its own body by throwing itself into the fire the man had built. The rabbit, however, was not burnt. The old man revealed himself as Sakra, a Buddhist deity. Sakra was touched by the rabbit's virtue and drew it's likeness on the moon for all to see. It is said the lunar image is still draped in the smoke that rose when the rabbit cast itself into the fire. A version of

this story can be found in Japan too where the rabbit's companions are a fox and a monkey.

Interestingly, similar legends occur in Mexican folklore, where people also identified the markings on the moon as a rabbit. According to an Aztec legend, when the god Quetzalcoatl lived in Earth as a man, he started a journey. After walking for a long time, he became hungry and tired. With no food or water around, he thought he would die. Then, a rabbit grazing nearby offered himself as food to save his life. Quetzalcoatl, moved by the rabbit's noble offering, elevated the rabbit to the moon, then lowered him back to Earth, and told him, "You may be just a rabbit, but everyone will remember you; there is your image in light, for all men and for all times."

The mythological Chinese moon, Jutho, is a beautiful young woman with a double sphere behind her head and a rabbit at her feet. In Sanskrit the moon is known as Sasanka which translates as “having the marks of a hare,” and Hindus tell a tale of their god Sakkria who took the hare in his arms to the moon.

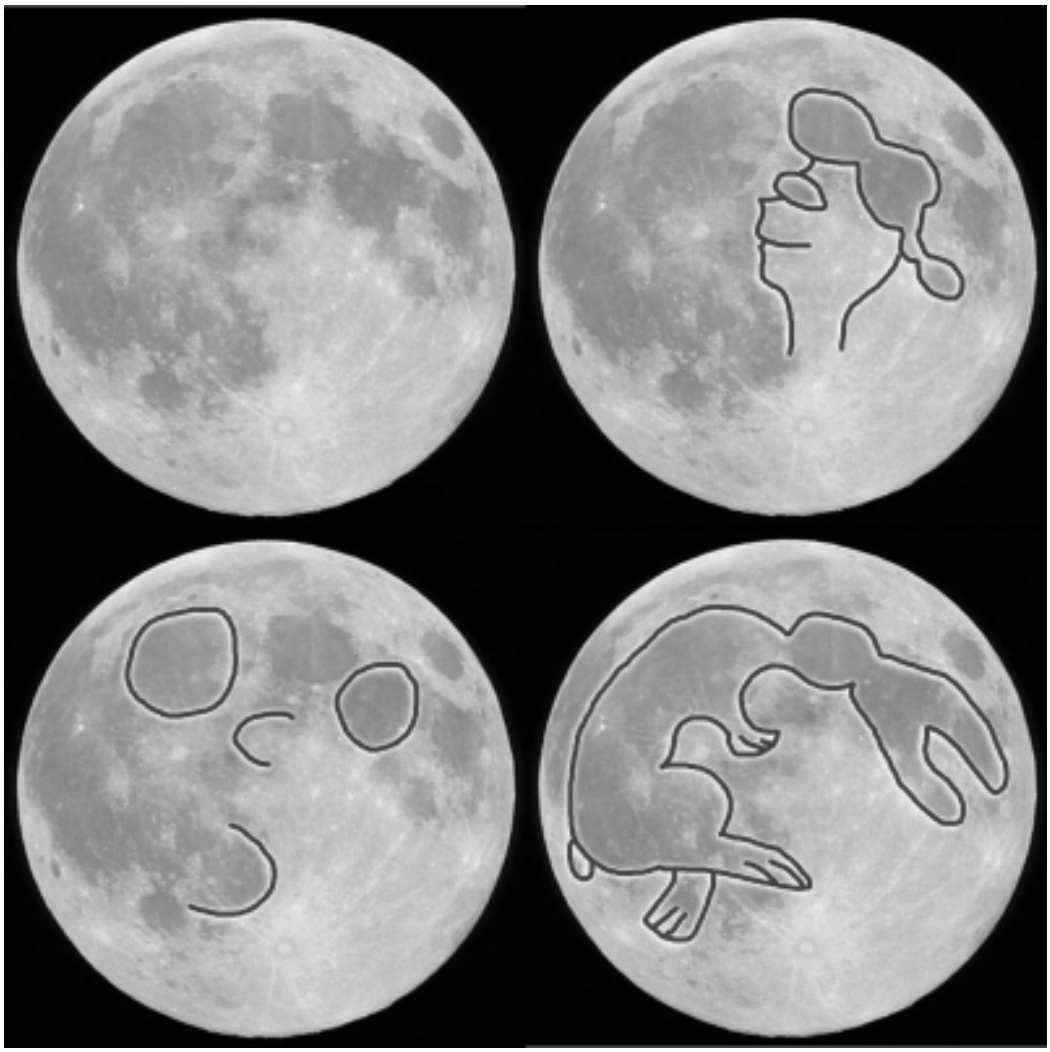
Humans have a propensity to imagine familiar shapes in silhouette’s of cloud’s, outgrowths or rock faces. Sky has been instigating human imagination at all times. Every culture has imagined familiar shapes in the pattern of stars. Moon and its dark and light patches obviously would have been objects to fantasize the world over. Folk tales are agog with stories of man on moon. If one civilisation imagined a dragon pounding a sack of rice, others saw the lunar world as home to rabbits, sheep, frogs and even dragons. Every culture made up at least one story to account for the dark patches.

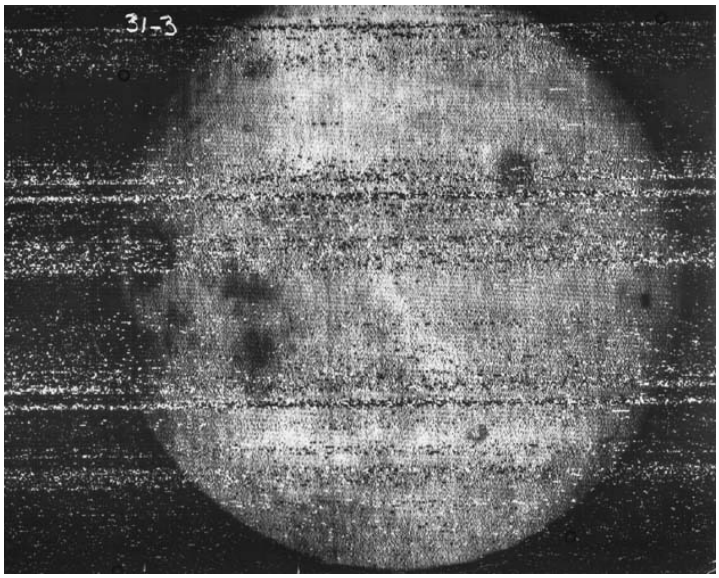


Exercise 4.2: What do I see on the face of moon?

Give the copy of the moon picture to every child/ group of children. Ask them to imagine shapes that they could make out of the dark and light patches on the surface of the moon.

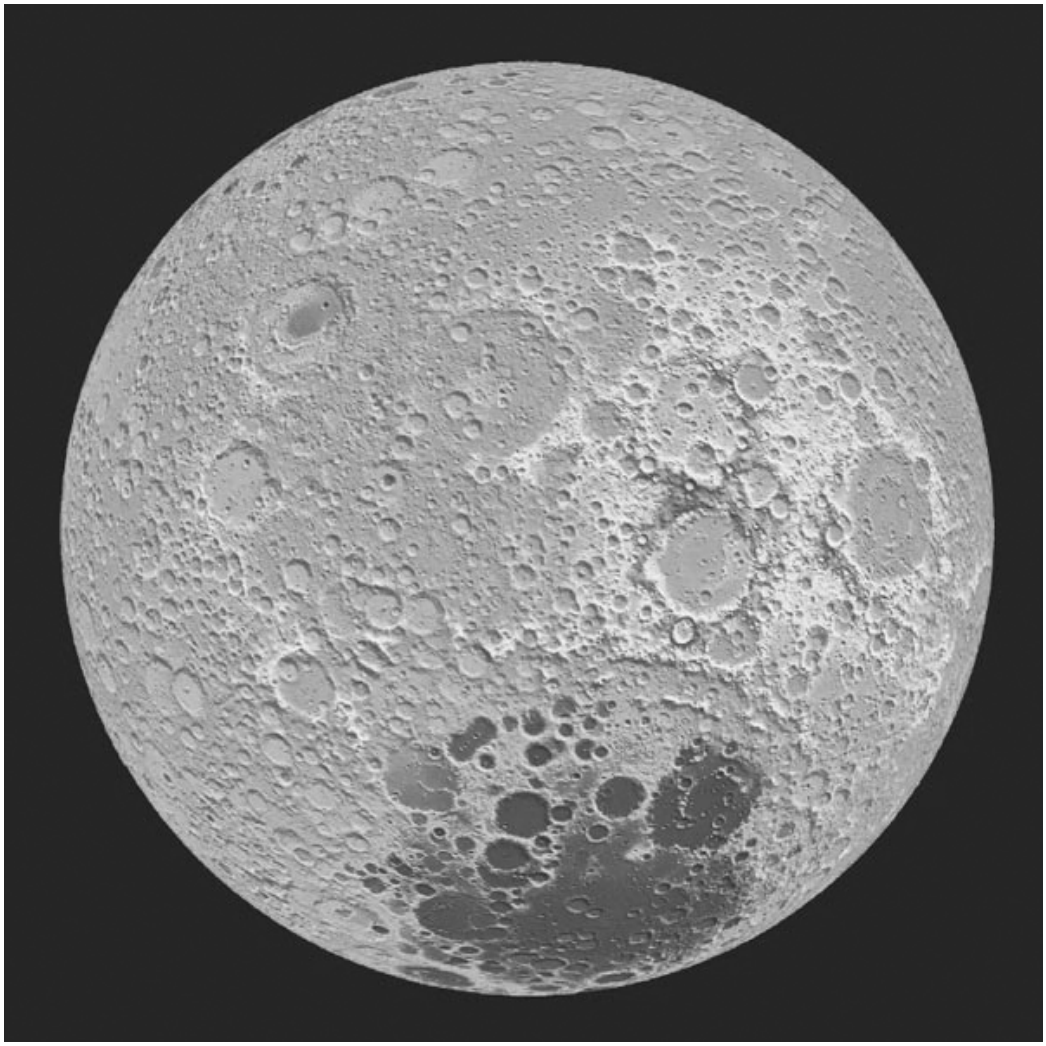
Emphasise at the end that we always see only one face of the moon- its near side and not the other (its far side). This is clearly visible from stories world wide. Most stories contain a rabbit character.





First ever photographs of far side of moon– taken by a Soviet space craft Luna-3 in 1959.

Photograph of far side made by a modern day sophisticated spacecraft



Exercise 4.3: How does the moon go around the Earth showing only one face?

Make three children take position as Earth, Sun and Moon. Tell then that while Earth rotates once a day, moon should move around Earth such that only one face – that is the moon persons face is facing the Earth. No one from Earth, that is from nose, ears or back, should be able to see the backside of the moon person.

Let many children volunteer to try out the motion. Soon one or two will get it right. Patiently wait and let children try. Only point out when they show their backside to Earth; i. e. when they do it wrongly.

After the exercise, tell the children that we have been able to first see the far side of the moon only in 1959, when Luna – 3 went around the moon. Show them the picture taken by Luna 3 and other spacecrafts of the far side of moon.

Exercise 4.4: Moon rotates around Earth; but does moon revolve around itself?

Earth rotates around itself (day) and revolves around sun (year). Moon revolves around Earth (month- or phases of moon); but does moon rotate around itself too?

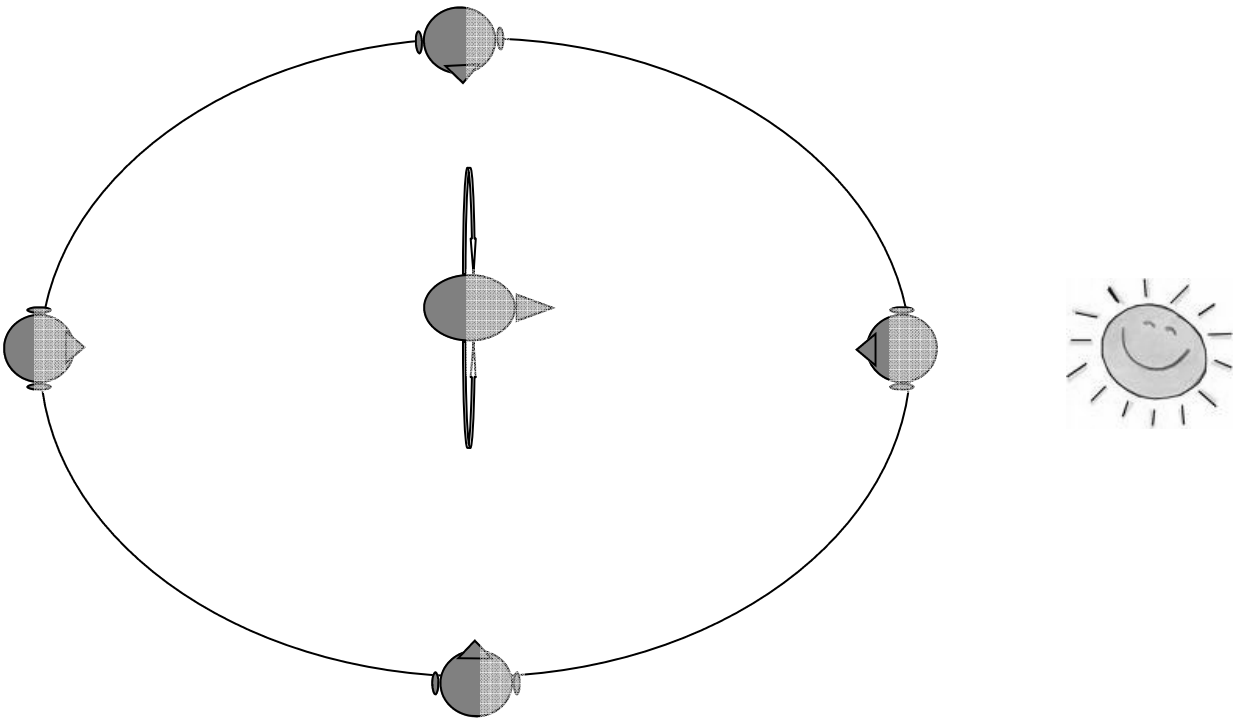
Most children will say no; having observed the earlier exercise. Repeat the exercise; ask them to observe carefully. Allow the children to voice their views.

Gently show that we call earth rotating about itself, when its nose (or ear or back) is aligned at various directions. At one time the nose is pointing east; then north, then west and then south. Make the moon go around Earth keeping its face towards the Earth person.

Now ask the children to observe the direction of the nose of the moon. Show that nose of the Moon is also getting aligned at various directions- east, north, west and south. Therefore moon also

rotates about itself! Only that its one day –moon day- is equal to 29.5 days, same as the time taken for it to go around Earth. In fact we see moon's one face because its rotation time and revolution time is same! It is one of the amazing facts to discover about moon.

To make the concept clearer we can use a chair instead of moon person. One face of the chair should be facing the Earth. Ask the children to move the chair around the Earth such that only one face of moon is facing the Earth person. Now they themselves will realize that they would have to rotate the chair to achieve it.



As the moon person revolves keeping his face towards the Earth person, notice that his nose is pointed to different direction. Therefore it also rotates on its own axis.

Activity 5
Motion of Earth around Sun

For the following activities essentially we need one child to act as Sun, one to act as Earth and 12 others to take the role of constellations in the ecliptic.

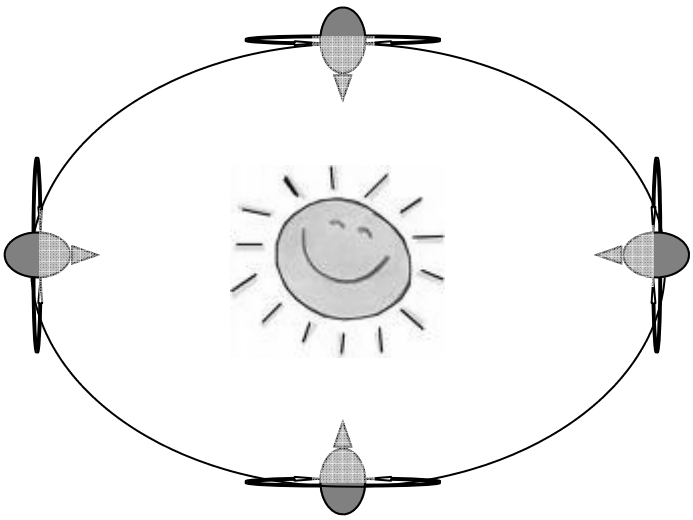
Two people from the class/ group are selected to role play Sun and Earth. Further 12 more children are to play the role of zodiac/ rashi constellations.

First place the sun at the centre. Mark a circle around the Sun and place the Earth person on it. Along the edges of the room keep wide enough place for 12 children to be kept equally spaced in a circle.

NOTE: All celestial objects rotate and revolve in counter clock wise direction. There are only few notable exception— Venus and Pluto revolves around its axis from East to West (clockwise); a moon of Neptune—Nerid rotates in retrograde (clockwise) direction.

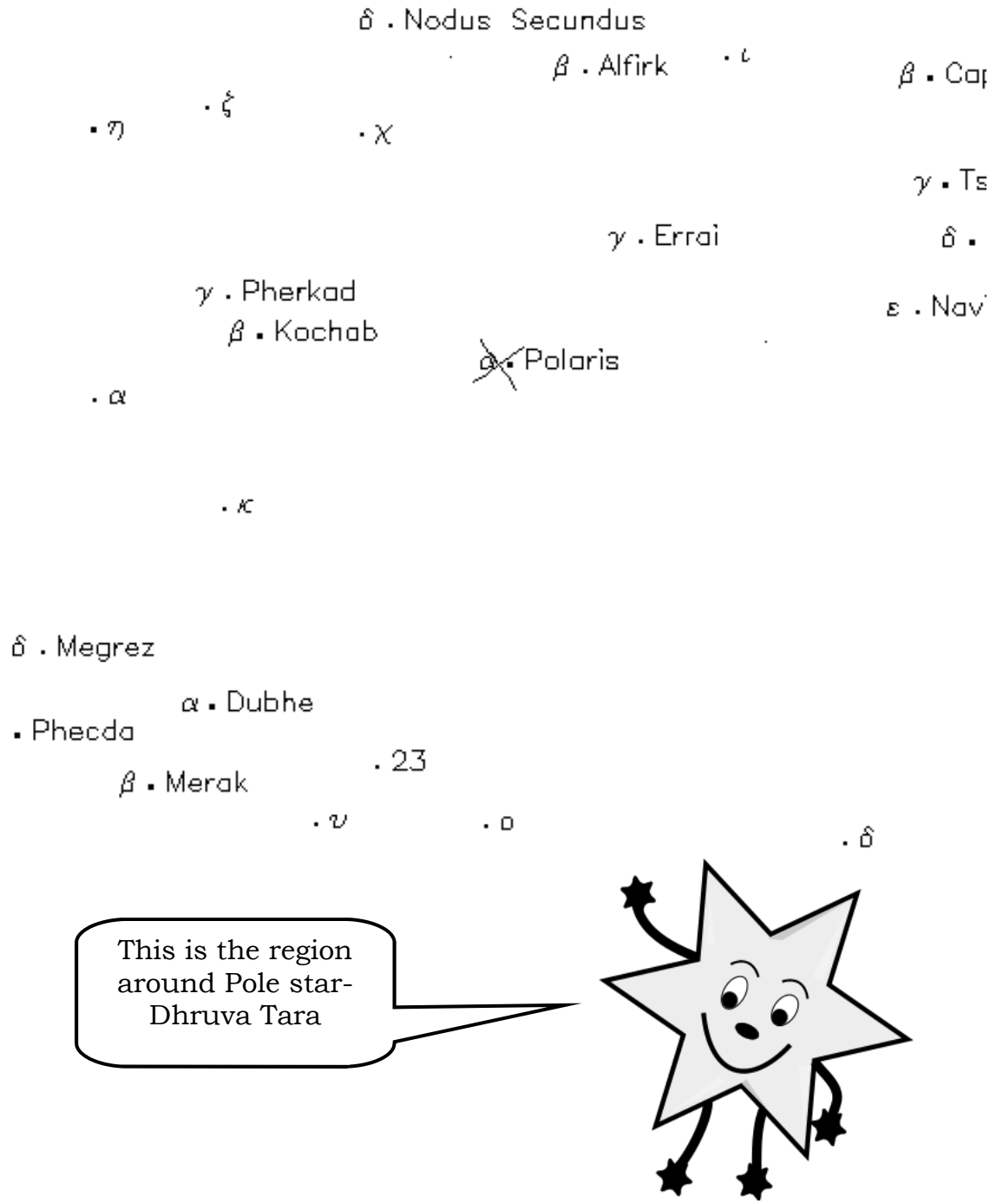
Exercise 5.1: What is a constellation?

Use the following two charts to explain. Show them chart 1 and explain that this is the region of night sky around the pole star



Noon positions at different times of the year for the Earth.

CHART 1


δ . Nodus Secundus
β . Alfirk
β . Cap
γ . Ts
γ . Errai
δ .
γ . Pherkad
ε . Nav
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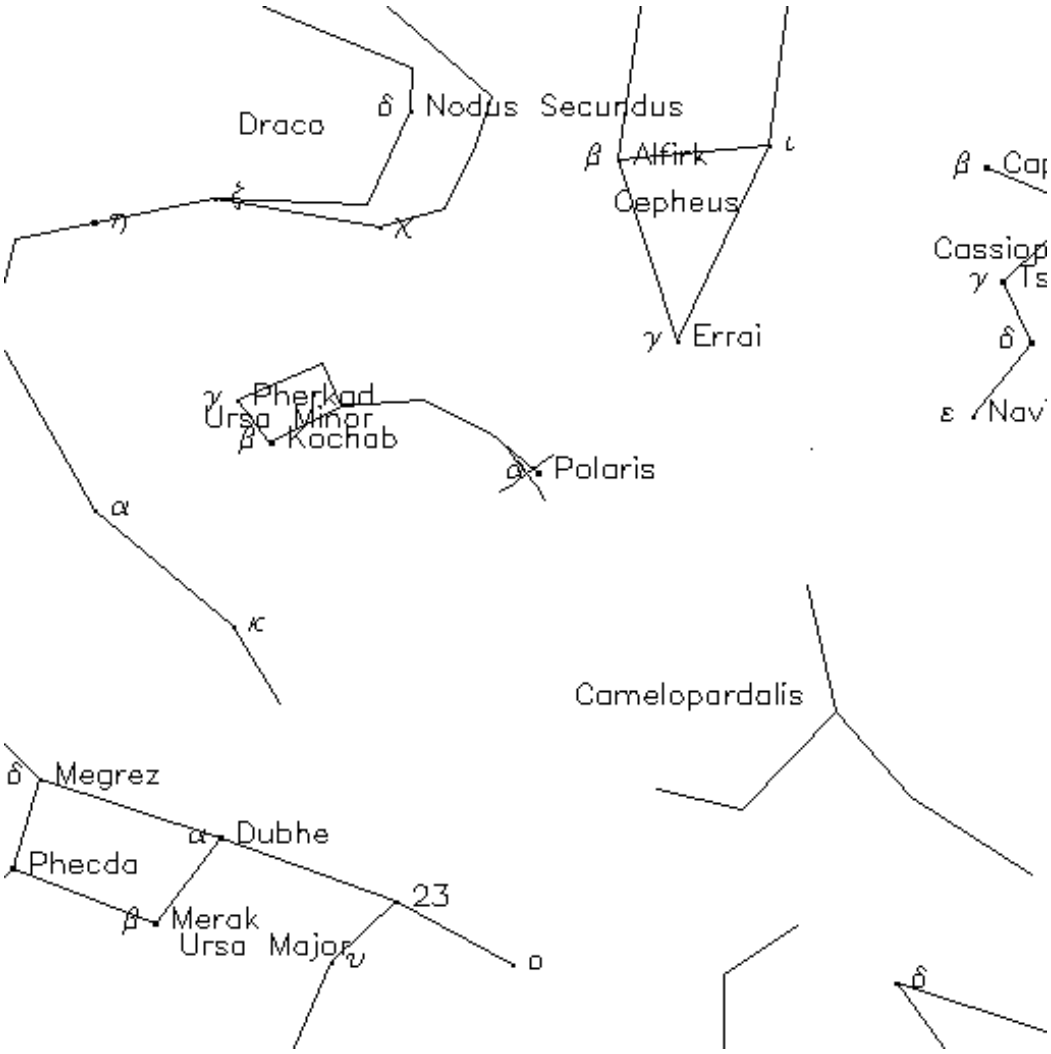
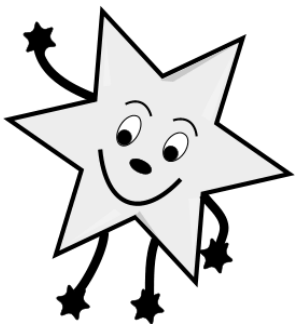
This is the region around Pole star- Dhruva Tara

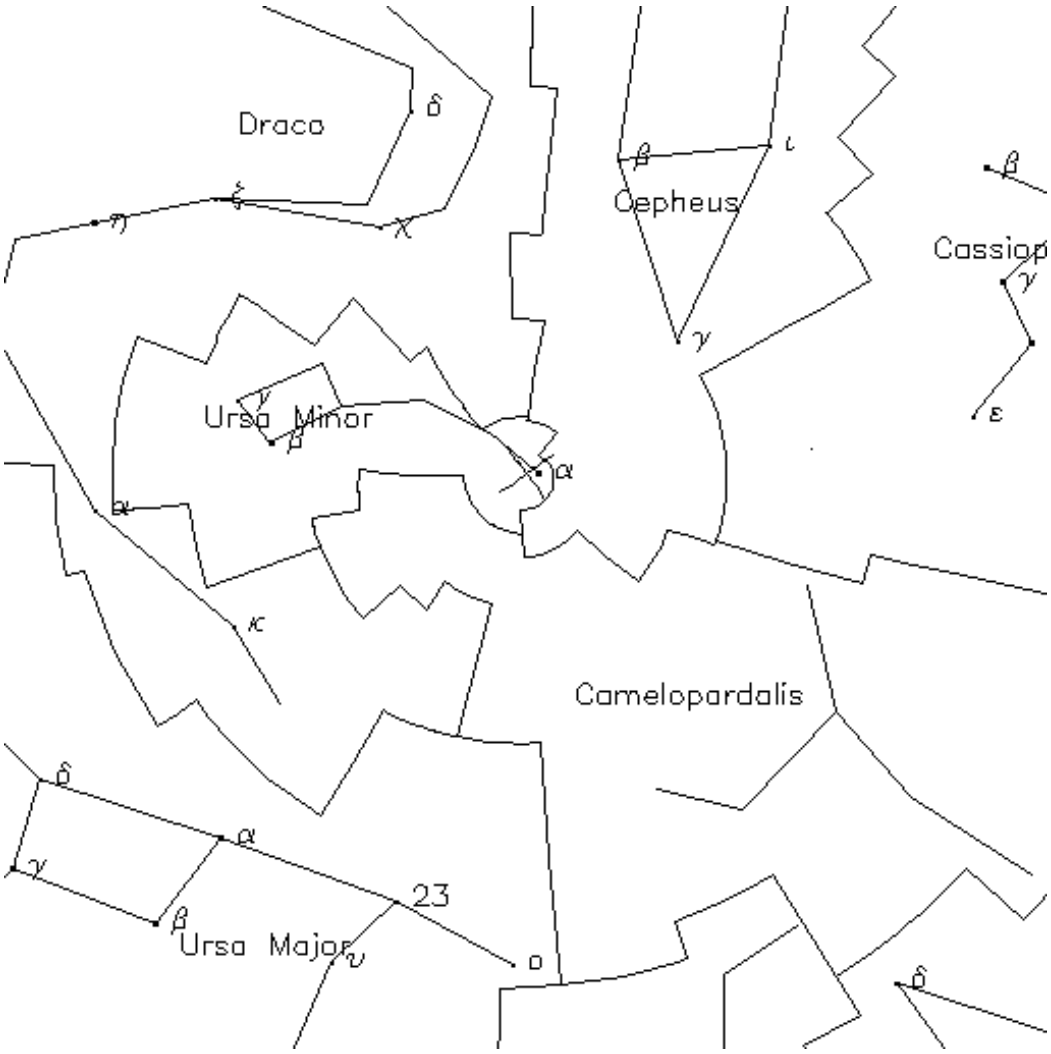
CHART 2



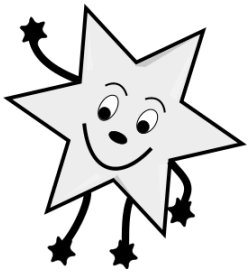


Now you can see that stars have been joined and made into shapes. Ursa Major (Saptarishri), Ursa Minor, Draco (Dragon/ serpent), Cassiopeia in the shape of W. Now it is easy to remember and identify stars.

CHART 3



Just like a land mass divided into Taluk, District and so on, a particular area in the sky is marked out with imaginary lines. These regions are called constellations. Now suppose say we see a comet in the sky, how do we communicate the same? With constellations, we can now inform others that the comet is seen in Draco. Thus constellations are useful for locating events in the sky. There are 88 constellations in all.



(Dhruv Tara). Show that they can see no pattern. Now show the chart 2. Ask them to notice how patterns have been imagined around stars. It is sort of joining the points and the imagining images. Chat 3 shows the regions marked out for each constellation. Thus, any event seen in the sky could be easily located.

Exercise 5.2: Earth revolves around the Sun- the time taken is one year

Repeat the rotation of the Earth to make children recap the orientation of Earth and the time at the tip of the nose. Make the Earth revolve around the sun. Repeat the rotation of Earth at various positions and establish the time at the tip of the nose.

Let the Earth person make one revolution and come back to the same position. Explain this period of time is what we call as a year ~ 365 days.

Exercise 5.3: Motion of stars in the sky

- Place 12 Rashi- person along the edge of the room; or far away from the Earth's orbit marked in the ground. Place all the 12 of them in a circle, equally spaced.
- Let the Earth person take position such that the tip of the nose is 06:00 evening. Sun will be at the western horizon. Ask them to notice the constellation- persons at the eastern horizon. Explain as the darkness fall, the stars at the eastern horizon would appear to rise above. There will be stars in front of the nose; these stars would appear to be above the head in the sky.
- Let the Earth person take position such that the tip of the nose is 12:00 midnight.
- Now a different set of stars would be above the tip of the nose. Explain that now these stars will appear in the night sky at zenith. Also a set of stars would be at the western horizon; these stars will set. Another set of stars would be at the eastern horizon.
- Let the Earth person take position such that the tip of the nose is morning 06:00 am.
- Sun will be at eastern horizon; another set of stars will be at the zenith and different set of stars would be setting at the western horizon.

- Let the Earth person rotate and come to 12:00 noon position. Explain now it is day time at the tip of the nose and no stars would be visible in the daylight. Also in that night or next few weeks stars behind the sun cannot be seen at all.

Repeat the exercise few times; and discuss with the children. Show that stars will also appear to rise in the east and set in the west; just like sun and moon.

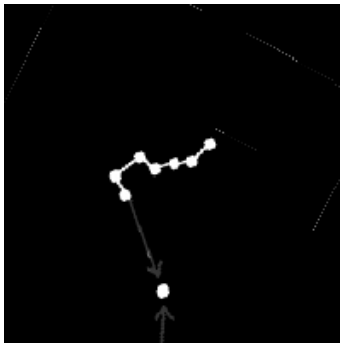
Exercise 5.4: Pole star

Earth is rotating around itself. As it rotates different parts of the sky come in to sight. This we see as rising and setting of stars.

Now hold a star like object above the head of earth person. Let the Earth person rotate. Ask the children to discuss what will happen to this star. Will it also seem to rise and set? Will it stay in the same place? Show them the time lapse picture on next page and explain that while all other stars rise and set, for people in northern hemisphere, pole star will be stay put. It would appear to be at the same place in the night sky.

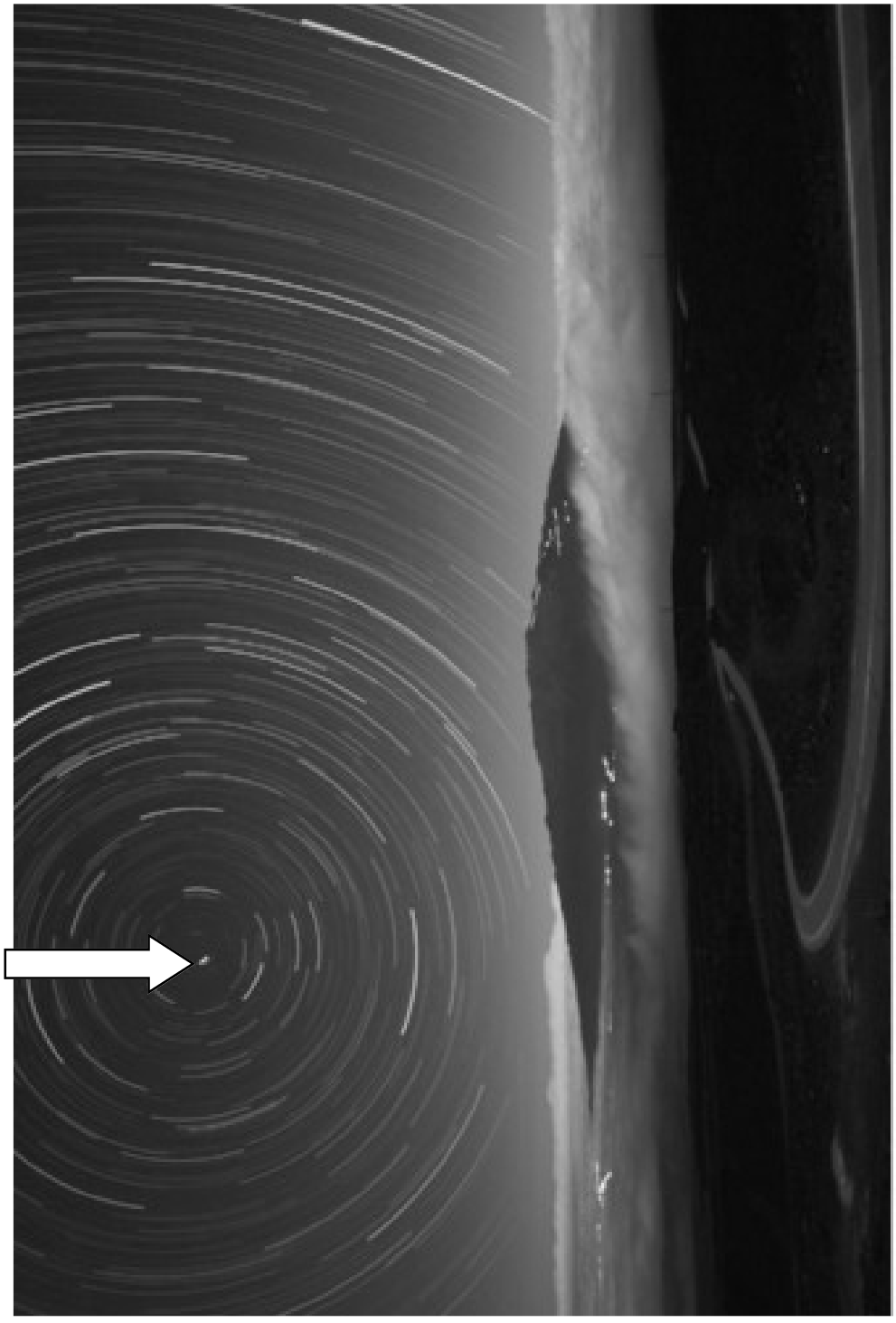
Exercise 5.5: How to find the north Pole star?

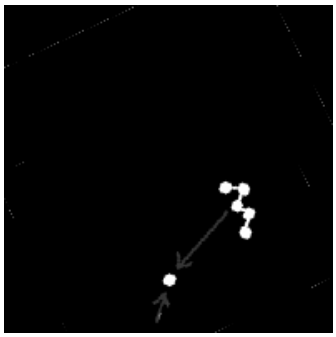
When you look at the sky for the first time, take note of the positions of the constellations. If you wait an hour or two and repeat, you will see that all the stars appear to move round, at a rate of 15 deg per hour. If you look on different dates and different times of the night you will see the constellations in different places. Take a careful note of the stars and constellations in the northern direction and you will be able to notice the north pole star, which does not shift.



An easy way to locate north pole star is with the aid of Big dipper constellation (Ursa major/ Saptarishi) that

Look at this time lapse photograph. The camera is kept open for many hours in the night; hence all the stars that move in the sky make a light trail. In the middle, the North pole star has not moved at all, hence makes a dot.





looks like a pan made out of seven bright stars. The end two stars are called the pointers and these two stars aim you towards Polaris or the Pole star.

Also the constellation in the shape of M (at times inverted in the shape of W) called Cassiopeia (Sharmistha) will also be a useful aid. If you can see this Cassiopeia constellation then you need to look for the pole star going upwards from the top of the W.

At one time in the sky, you would either find the Big Dipper or Cassiopeia, which can lead you to Pole star.

Make a Saptharishi finder

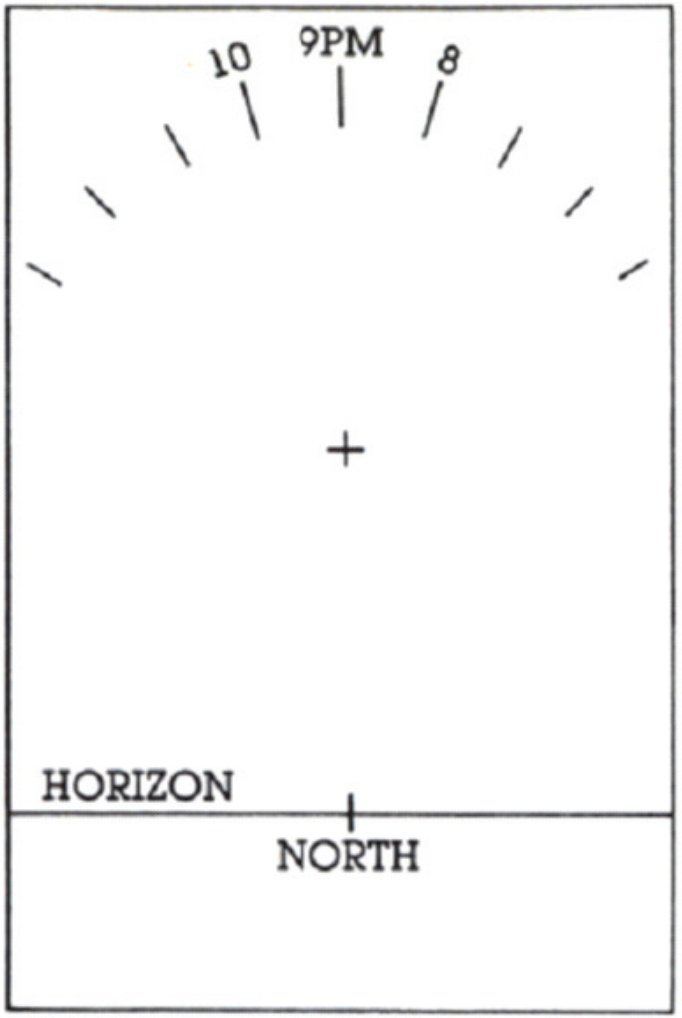
Cut out the circle and rectangle. You may like to paste them to a stiff board. Trim the edges to the exact size of the circle and rectangle. Fasten the circle to rectangle by putting a ball pin or suitable material (eg. paper fastener)

How to use

Line up the date of observation with the time of observation. For example, if it is 8 pm on April 11, turn the month wheel until a point into space marked “April” is aligned with 8 pm on the rectangular card.

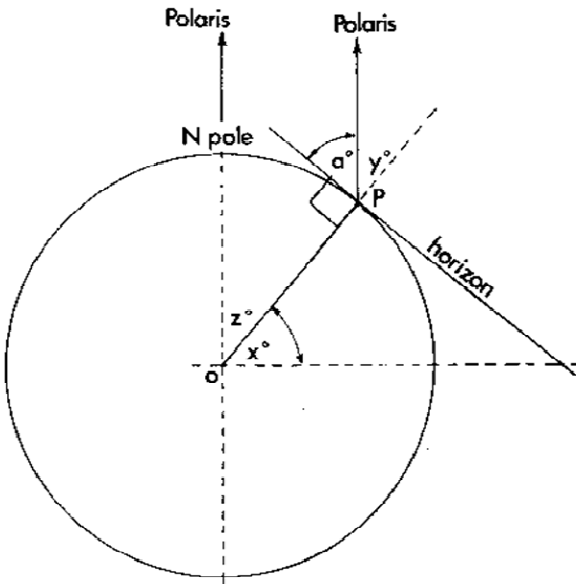
First locate the north direction with the help of pole star. In the same direction look at the horizon line dividing the earth and sky. Hold the card up so that the line marked as ‘north horizon’ corresponds with the north horizon in the real sky. Now the Saptharishi will appear in the sky roughly where you see it on the finder

How to find the Saptrarishi



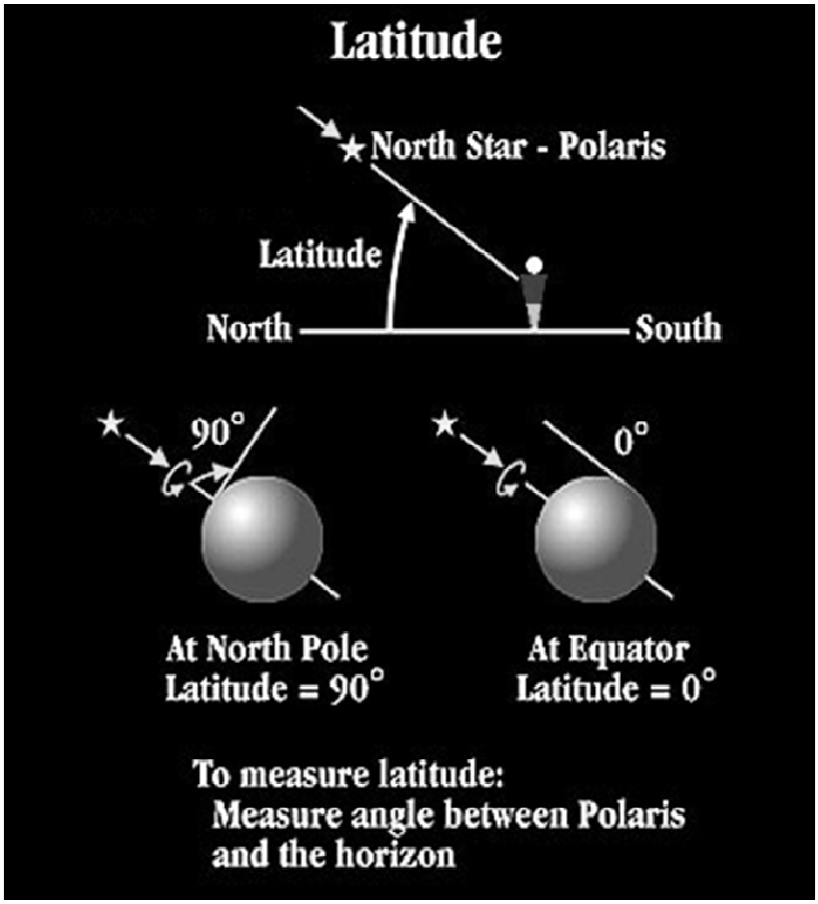
The dipper finder/ saptarishi finder provided herewith is made for higher latitude. We know that for a person in Kashmir stars below the pole star would be visible and hence part of big dipper may be visible below the pole star. However for a person in Thiruvanahta-puram, pole star would be so near the horizon that no star below the pole star would be visible. Therefore, in the above finder one can know where the dipper will be, even if it is not visible to us at that point of time.

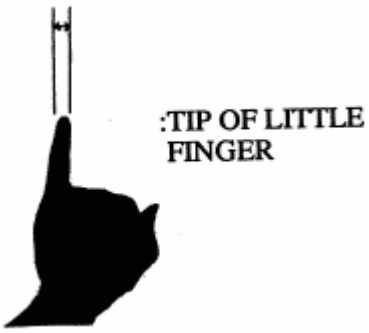
Measure Your Latitude

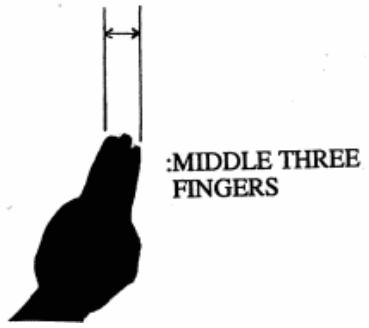


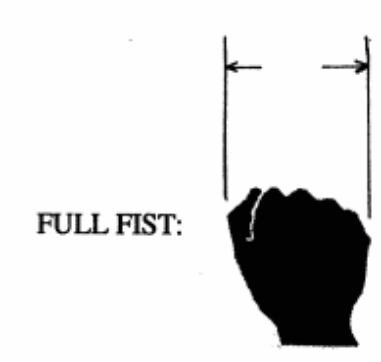
Assume you are at P. The Polaris would be inclined at an angle 'a' from the horizon. This is the tilt that you will have to make with your head to see the pole star. This is also your latitude as you can figure out geometrically from the diagram!

Therefore by observing the pole star and measuring how high it is, you can calculate your latitude.







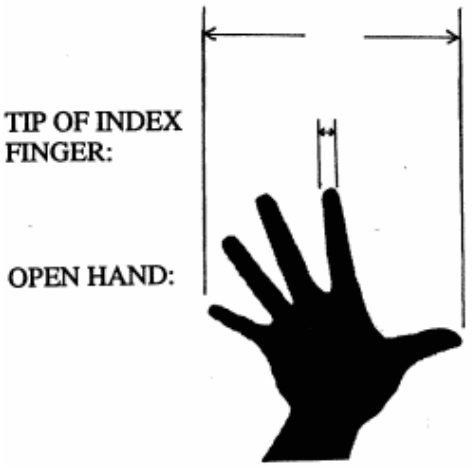


You can use your fingers to make a rough measurement of the angles of the celestial objects. For this keep your hand and elbow fully extended and stretched before you.

1/2 degree

- Breadth of the little finger would be about 1 degree;
- three middle fingers 4 deg;
- full fist 10 deg;
- point finger 1.25 deg
- and open hand 18 deg.

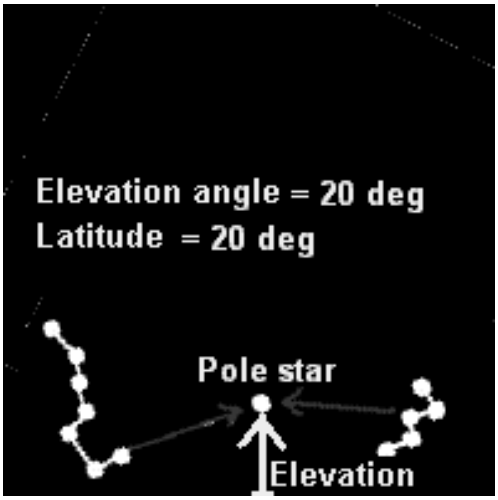
Full moon will be only 1/2 degree in the sky! Measure and check this.



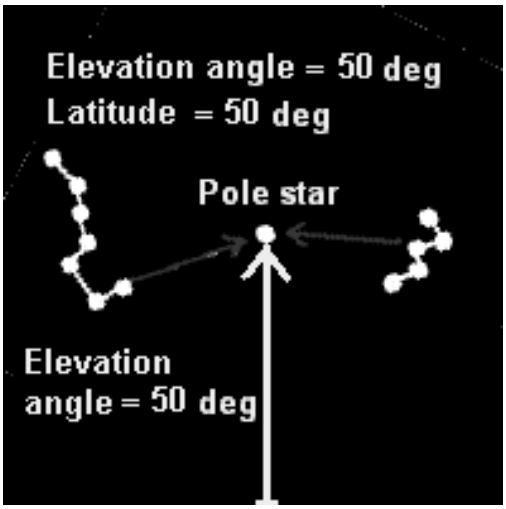
NOTE: This method is valid only for very very distant objects and cannot be used for measurement of angles between objects on Earth's surface.

Exercise 5.6: How high will be the Pole star?

When the children identify the pole star tell them to notice how high it looks. You can make a contraption as described below to explain that as one moves towards north the pole star will appear to move high. You can notice that for two people A and B the height of the pole star will differ and for a person at North Pole the pole star will be right on top of the head.



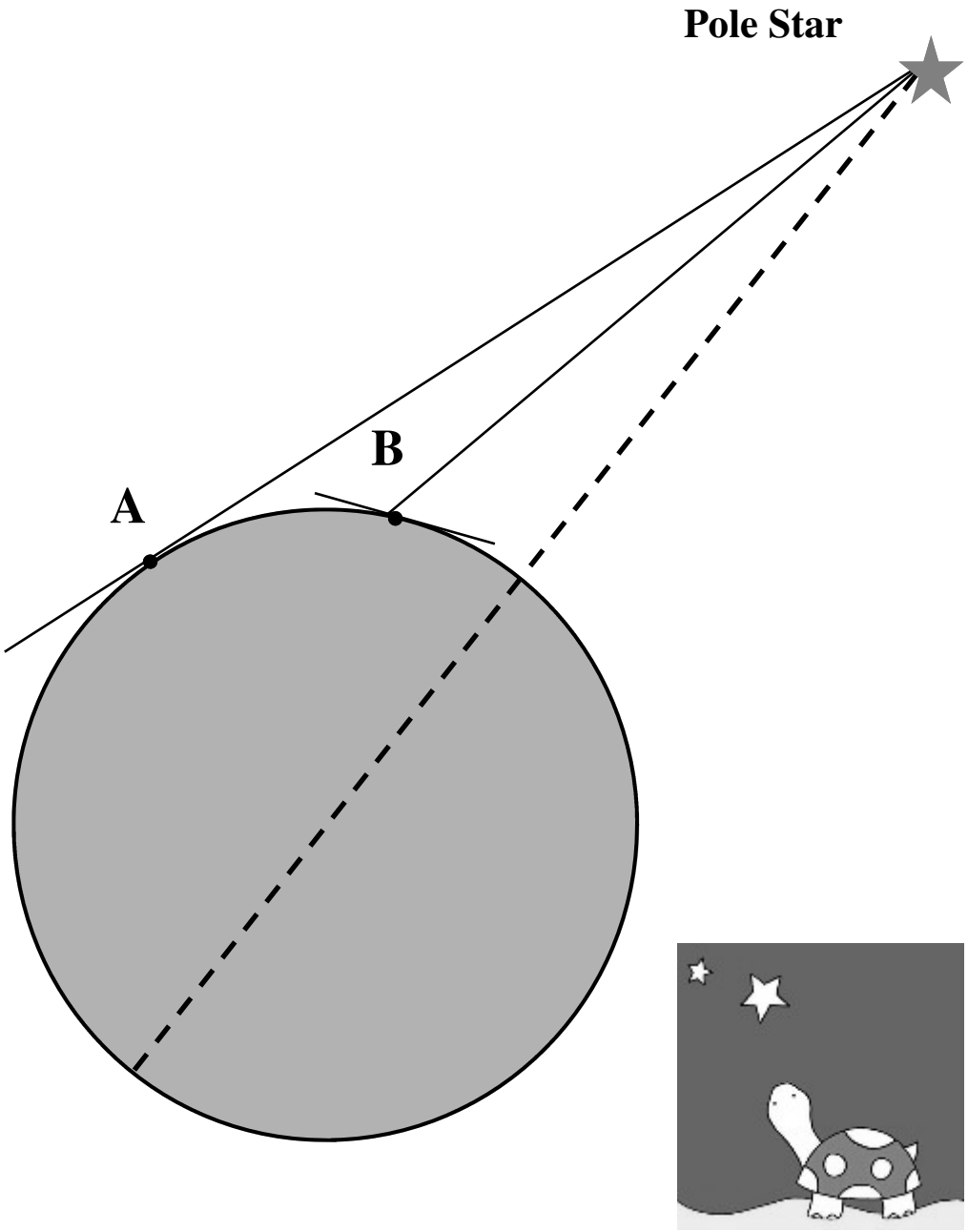
A



B

How to make the contraption?

Take a slightly rigid plastic ball. Use a bicycle spoke rod or a thin rod to pierce it through its North and South Pole (two opposite points on the surface of the ball). Now fix one end of the rod as North Pole star. Take a length of string and tie it at the 'North Pole star' point and tie the other end at point A on a pin. Take another string and tie it between point B and North Pole star. You will see that the angle of depression is different and hence pole star will appear at different height from these two points.



For a person at A, the pole star will appear at the horizon, that is level to his head and shoulders. S/he need not lift the face up. But for B, the pole star will be above the horizon, that is s/he will have to look up. For a person at north pole the pole star will be right at the top of the head and hence he/she will have to tilt the head up. This is the angle of depression.

Exercise5.7 What is Ecliptic (Sour path; Kranti Vrith – or orbit of Earth around the sun)

Before we begin this exercise children should be clear that Earth is suspended in space; and going around the sun. In our role play identify that Earth is only the head. The body and legs are actually not there at all. So we should imagine Earth to the head floating in the space- like an insect is suspended in the air.

Also make clear that stars are not only the 12 children placed around in the edge; but stars are to be found underneath in the floor, over head and in all directions surrounding the earth person. In fact, the North Pole star will be at the top of the head.

Now let the Earth person revolve around the sun. Let the earth person take positions along the path at various locations. From each location mark the apparent position of sun against the stars.

Ask them to imagine the track the sun will follow in the sky as earth goes around the sun. On any given day, the sun will trace a half circle in the sky. Over a year, the sun will appear to move in a circle . This apparent path of the sun in the sky is the ecliptic. It is a strip over which the moon and planets also move.

Exercise 5.8: What are rashis?

For this prepare 12 cards with the names of 12 rashis (zodiac signs). We know that one year is 12 months. So we divide the ecliptic into 12 equal parts. On each part one group of stars (a constellation) has been given the name of a Rashi or Zodiac sign.

Now let it be January. From the point of view of the Earth, the sun will appear against a group of stars; one star-child will appear behind the sun as seen from Earth (which means he will be hidden behind sun and cannot be seen during this month). This constellation would be Sagittarius. Give the card named Dhanu to that child. Let him/her hold it.

Explain the concept of constellation - stars in a region are grouped together. Some shape is imagined and thus the constel-

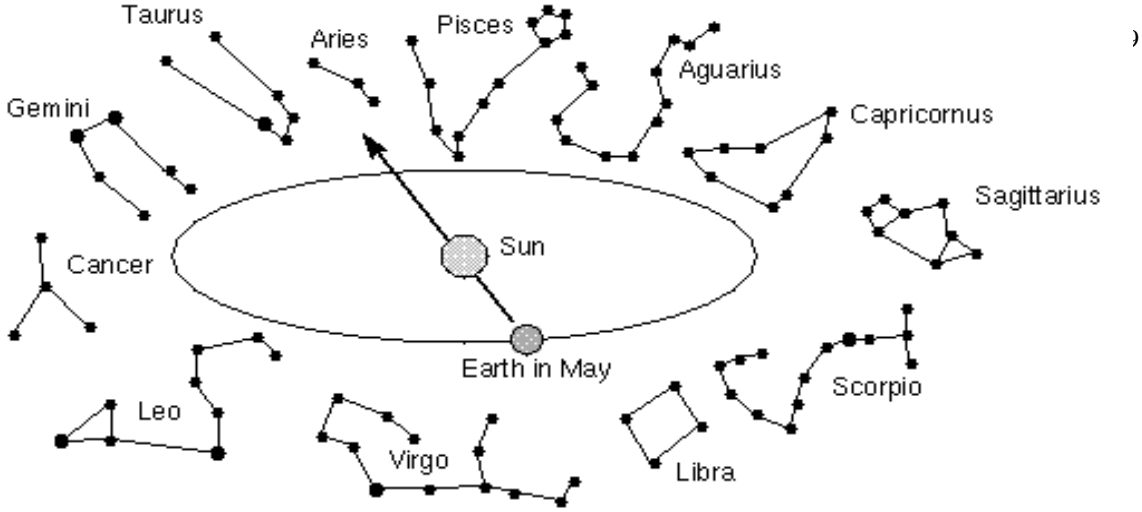
lations gain a name. Actually, constellations are a region in the sky- like district is a region in a state.

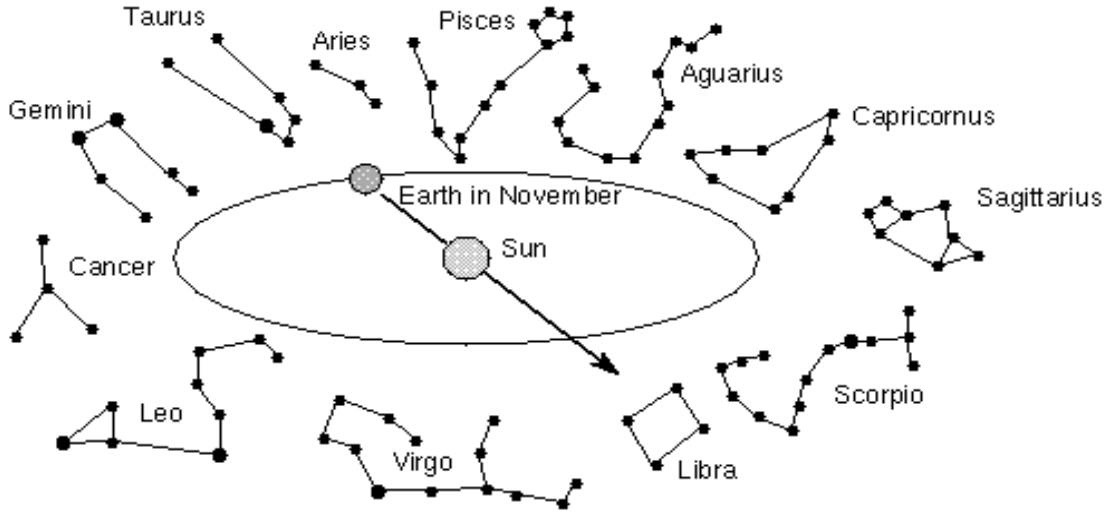
Now let Earth move to the position marking February. Now another star-child will appear to be behind the sun. This constellation will be Capricorn. Hand over the card named Makara to the constellation person.

In like manner let the earth move around the Sun and hand over the Rashi name cards to each constellation. As the child move from one position to another; sun will appear to move from one constellation to another. These 12 constellations are called Zodiac (Rashi)

Zodiac	**Rashi**	**Month (aprox)**
Sagittarius	Dhanu	December- January
Capricorns	Makar	January - February
Aquarius	Kumb	February - March
Pisces	Meen	March- April
Aries	Mesh	April-May
Taurus	Vrishabh	May-June
Gemini	Mithun	June-July
Cancer	Karka	July- August
Leo	Simha	August- September
Virgo	Kanya	September- October
Libra	Tula	October- November
Scorpios	Vrushchik	November-December

After all the cards have been handed over, let the Earth person take positions along its path. Ask the children to guess what Rashi/ Zodiac it is.

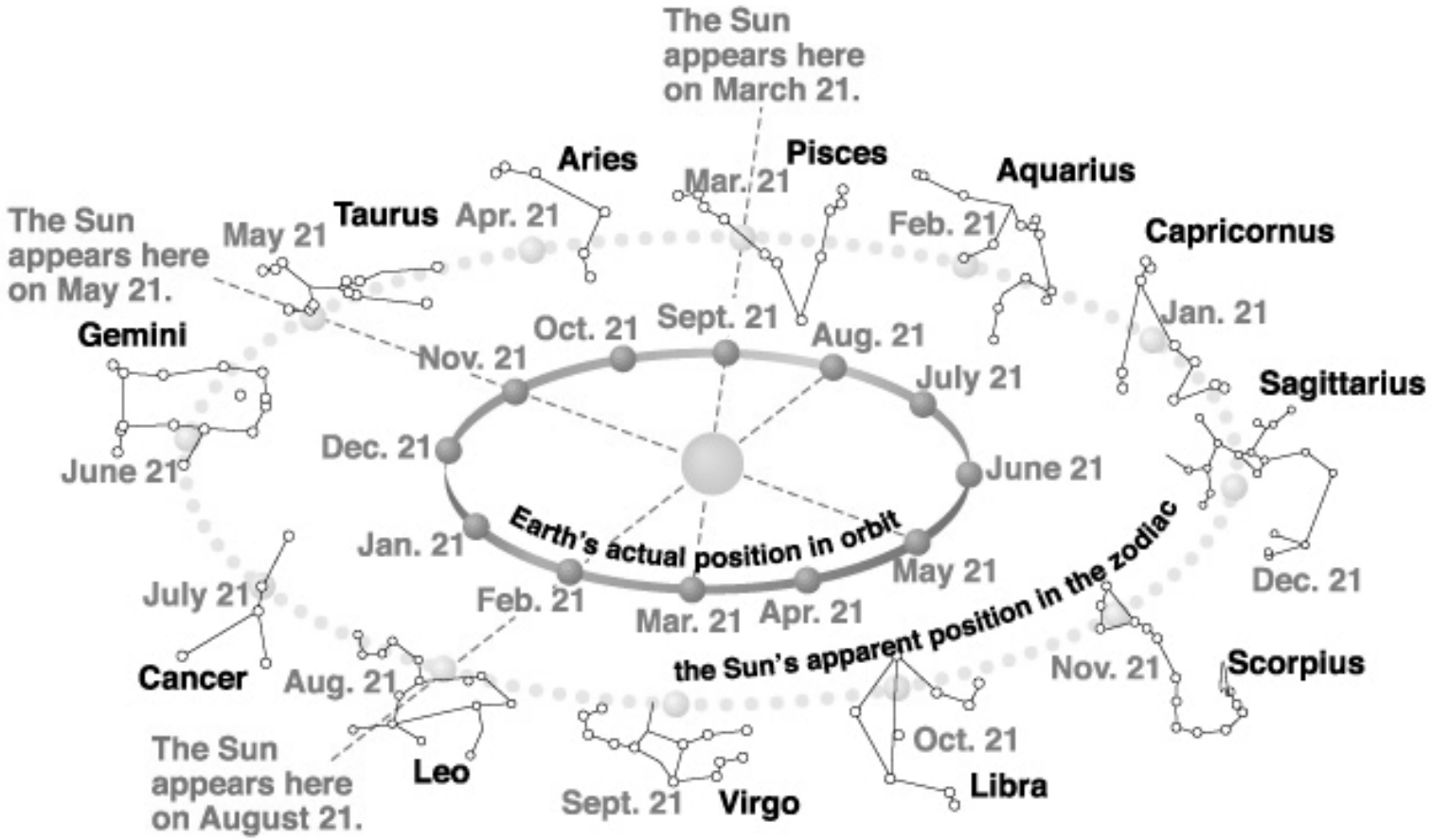




Note for the RPs

Astrology is bad astronomy!

Some ideas of astrology would be known to some participants. They may be confused about what they know of as astrological information and what is stated above as astronomical information. For example in Indian astrology sun is supposed to enter into Mesha rashi only on April 14, whereas actually it would have already entered Mesha on March 21. This difference in astrology is due to the fact that astrology is built on bad-astronomy!. Astrology is not a science and hence one could see it to be full of errors.


The Sun appears here on March 21.
Aries
Pisces
Aquarius
Mar. 21
Feb. 21
Taurus
Apr. 21
May 21
The Sun appears here on May 21.
Capricornus
Jan. 21
Gemini
Oct. 21
Sept. 21
Aug. 21
Nov. 21
July 21
Sagittarius
Dec. 21
June 21
June 21
Earth's actual position in orbit
Jan. 21
May 21
Dec. 21
July 21
Feb. 21
Mar. 21
Apr. 21
the Sun's apparent position in the zodiac
Nov. 21
Scorpius
Cancer
Aug. 21
Oct. 21
The Sun appears here on August 21.
Leo
Libra
Sept. 21
Virgo

Activity 6
Motion of Celestial sphere

Exercise 6.1 How many Rashis can you see in a night

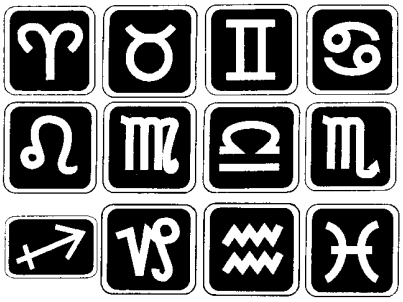
Of course a very correct scientific answer to this will depend on the time and location. However we are looking at an approximate idea.

Now Earth rotates around itself in 24 hrs. That is 12 hrs of day and 12 hrs of night (we know that days and nights vary in length but we are not considering that here.)

Bring the earth person at evening 06:00 pm position. Now Sun is setting at the western horizon. We know that at any time we see half of the sky (we cannot see what is at our back). Therefore we would be seeing 6 rashis in the sky at that particular instant, including the rashi that is rising.

Now let the earth person rotate slowly. We may observe that some rashis are setting as new ones are rising.

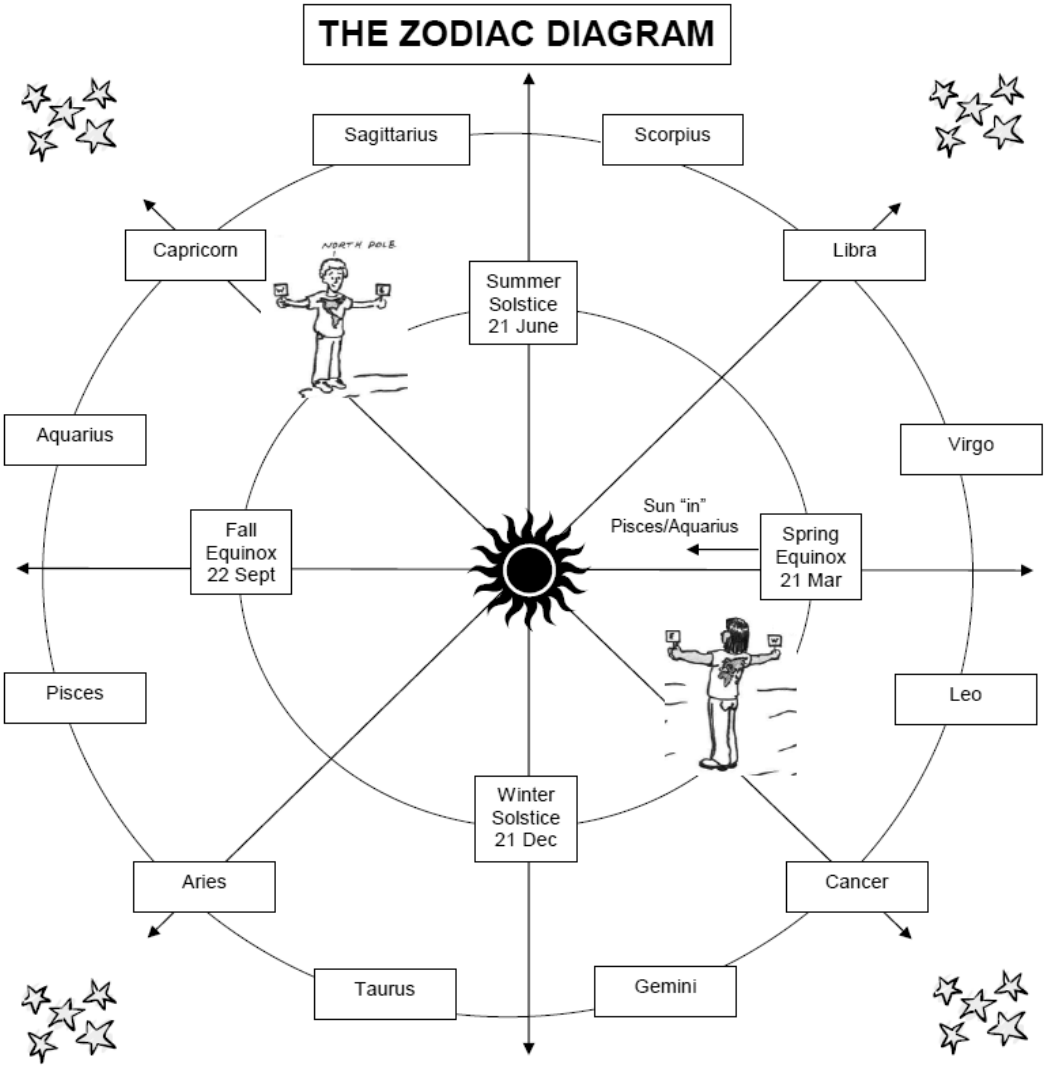
Earth rotates about itself once in a day or in 24 hrs. In that period, if there were no sun, the nose person would have seen all the 12 rashis. All the 12 rashis would rise in the eastern horizon once in a day irrespective of whether we are able to see them or not. Some may be right behind the sun and sunlight may block their visibility. In other words, every 2 hrs one particular rashi will be rising at the eastern horizon and then the next one will rise. If we consider the night consisting of 12 hrs, the rashi that is rising at 6 pm will go on till 8pm. The next rashi will rise at 8 pm; another one at 10 pm, another at 12 pm, 2 am, and 4 am. By the time the next one rises at 6 am, it will be sunrise and that rashi will be behind the sun and hence not visible. Therefore ideally one should be able to see all the remaining 11 rashis. However practically one can see about 9 rashis comfortably.



Exercise 6.2: Rashis visible at zenith at midnight

As Earth moves from one month to another; notice how the stars visible in the night sky change.

Let the Earth person take position in the month of mid-January. Mid January is the time when Makara (Capricorn) Rashi starts, i.e the sun is 'in' Capricorn. This means Makara will be behind Sun, will be rising and setting with the Sun and hence cannot be actually seen from Earth.



Identify the zodiac sign that is overhead at midnight. It will be the rashi opposite to Capricorn (Makara). The one that will be overhead at midnight will be Cancer (Karka).

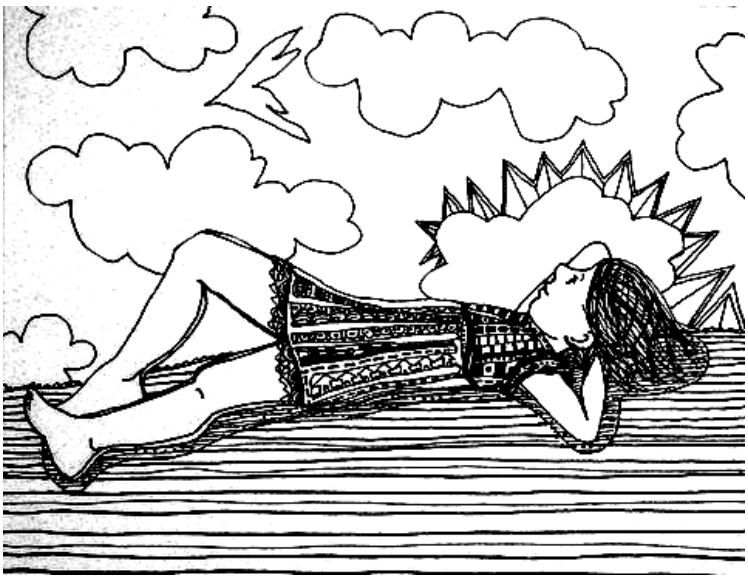
Now let earth take exactly the opposite position; that is mid–July. The Sun is 'in' Cancer (Karka) which means cancer is being hidden by the sun on the opposite side. The rashi directly overhead at midnight is Makara.

Similarly fix the two middle earth position of mid– April and Mid–October. Identify the rashi which the sun is 'in' or against, and the rashi directly overhead in midnight. These will be Aries (Mesha) and Libra (Tula) as can be seen from picture. Make children stand at these location with the Rashi name card.

Identify the rashis that the Sun will be 'into' and the one that will be overhead at midnight during various months, and complete the zodiac with 12 children with the name cards.

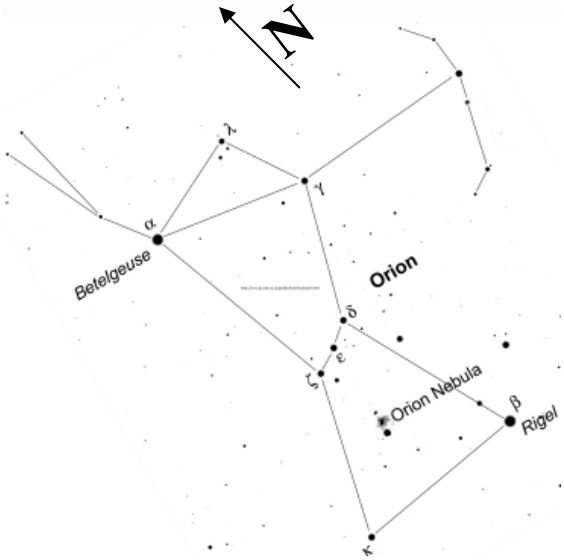
Suggestion:

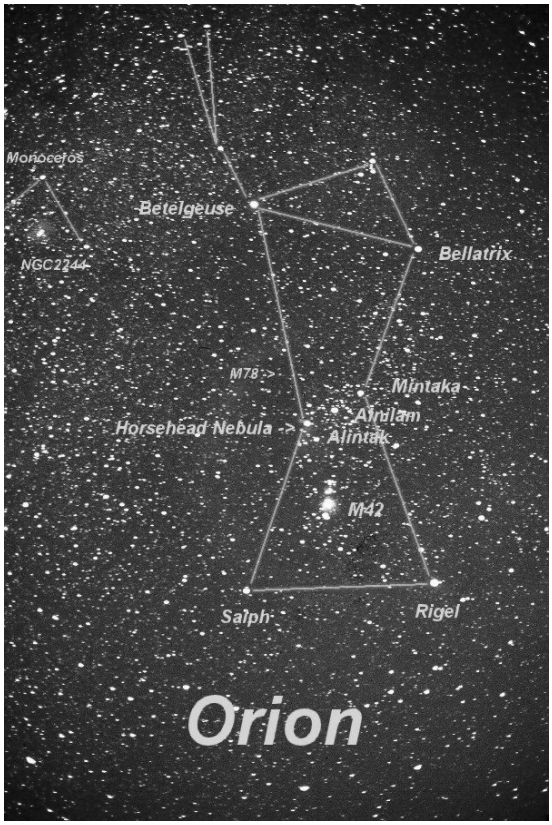
Once the Zodiac is complete with various Rashi children in position, specifically concentrate on the current month. Notice which Rashi will be progressively visible in the night sky. After knowing their rough timings the viewers will be very excited to actually identify them at night and verify their newly acquired knowledge.

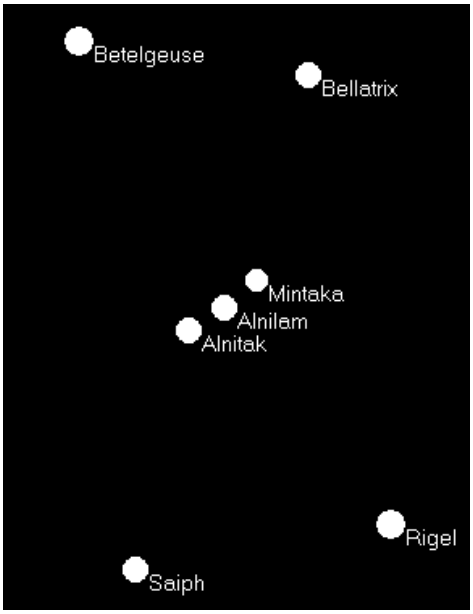


Exercise 6.3 When will we see Orion?

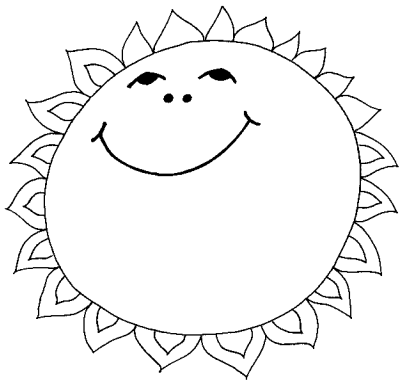
Orion (Mrigashirsh) is a prominent constellation in the sky visible in India. It is located somewhat between Tarsus and Gemini. Through role play explore which part of the year it would be visible and when it will not. Also explore the timing of its rising and setting.







Four stars that is at the outer edge of Orion are very prominent. Three stars that form a straight line in the middle are hard to miss.



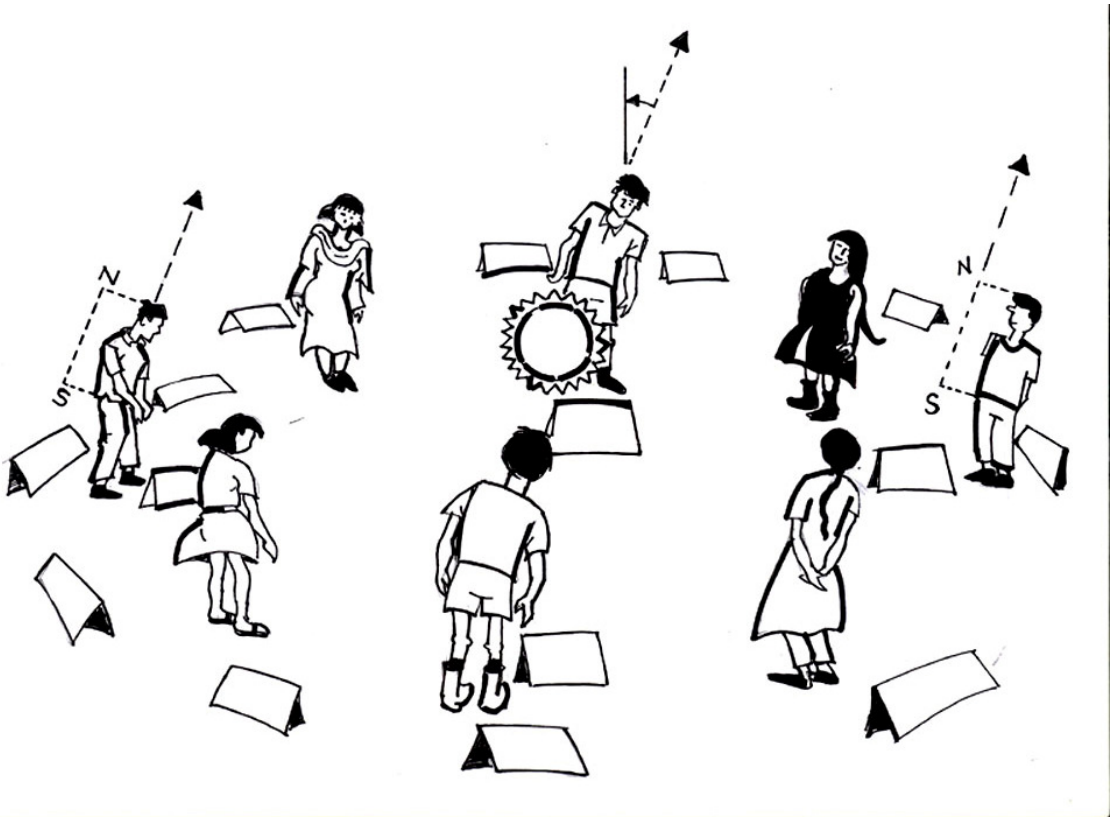
Activity 7
Earths tilt and seasons

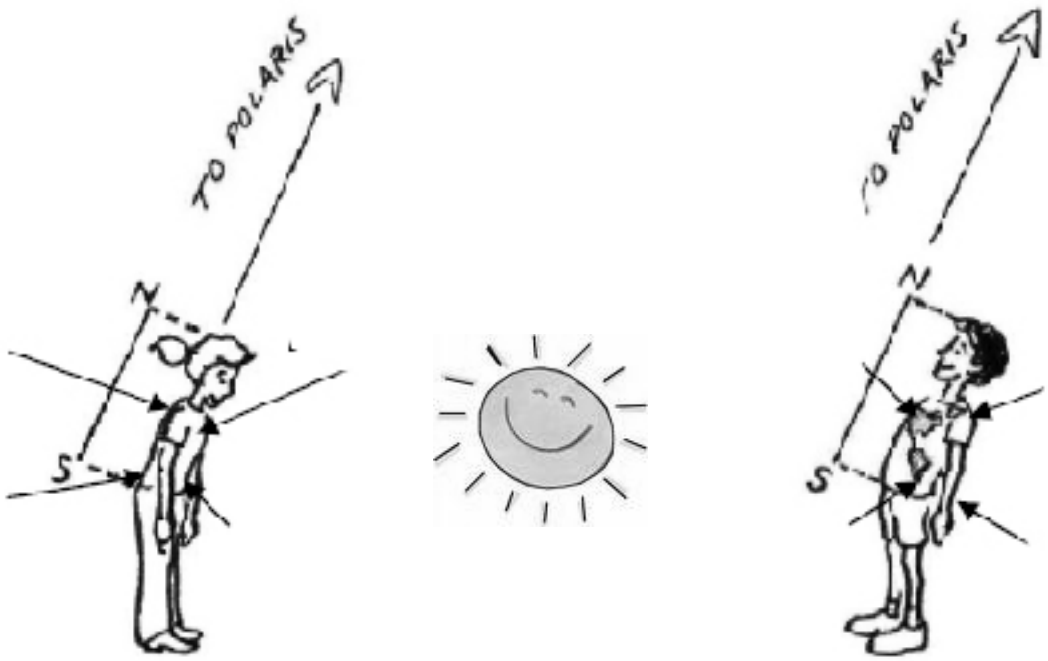
All through these activities we have considered as if Earth rotated straight up. Actually Earth's axis is tilted. Inform the children of the same. May be you can show how the axis of earth is tilted by showing a globe mounted on a base. The tilt is 23.5 degrees.

To make them understand the amount of tilt, show then what is 90 degrees, what is 45 degrees (half of 90) and 23.5 degrees is about half of that. Ensure they are familiar with this.

Exercise 7.1 The tilt of Earth is towards Polaris (points to one direction)

- Make the Earth person tilt the body at the waist about 23.5 deg from the vertical. Now ask the Earth children to go around the sun.





- Often the children will tilt towards the sun while they go around it.
- Now let the child take the position of June, with the tilt. Let them tilt 23.5 deg towards the sun at the waist.
- Now point out that top of the head is towards the pole star – Polaris. Identify some object in the top (a point on the roof, top of a tree etc..) and let the children assume it to be Polaris.
- Now ask the child go around the sun and let earth person take the position of September.
- Most often the earth person would still be tilting towards the sun. Point out how the direction of pole star has shifted. Tell the children that there is some error in the way they are positioned.
- After discussion, the children will discover that they should keep their tilt towards one direction while going around the sun.
- Tell the students that Earth also goes around the sun keeping its tilt pointed towards the same direction. Demonstrate this using a globe or a ball pierced with a spoke rod (representing the axis)

Exercise 7.2: Where is the sun during summer and winter

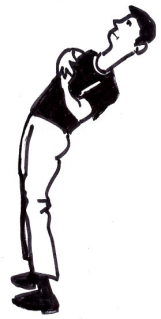
- Ask the earth child to take the position of June (being summer). Let the child take a position facing sun. That is, it is 12:00 noon for Mr nose.
- Ask the child to rotate slowly to simulate day and night. It will not be easy, especially keeping the orientation of their tilt.
- Have all children to try to rotate their bodies through a complete day in the appropriate direction (toward the east) around their tilted axis. Guide children to keep the tops of their heads oriented in the same direction toward Polaris. Give children 30 seconds or so to enjoy exploring this on their own. This action is physically challenging, requiring changes in the bend at the waist. It generally does not go well on the first try but children enjoy trying it.

Dawn

Noon

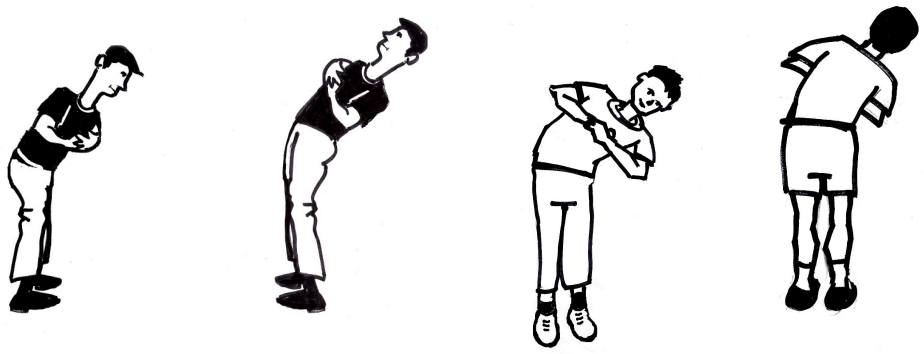
Dusk

Mid-night



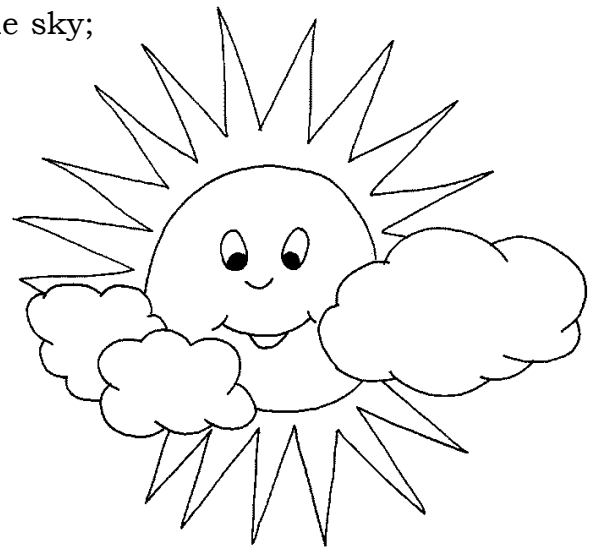
NOTE: The tilt; or the head is facing towards one direction only as the Earth person rotate around himself.

Noon position during June, December, March and September



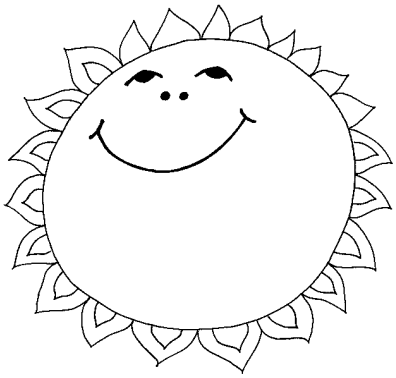
- Once they get the hang of it they will understand that for midday they should lean forward, for morning and evening they should bend at sides and for mid night bend backwards. Actually they need to get the hang of these four time-positions.
- In the tilted position, the Earth persons head can be treated as Northern hemisphere, to show inclination with respect to sun's rays.

Now ask the earth person to look at the sun from midday position from the summer point (June). Let the person move to winter point (December) and take midday position . Let them look at the sun. Ask them to guess where will the sun appear in the sky? Low towards the horizon (the Nose will have to tilt her head to look down) or high on the sky (Nose will have to tilt her head up to look at the sun). Few trials would show that
during summer the sun is high in the sky;
winter low in the sky.



Now let them take positions at mid-point of summer and winter i.e. March and September positions. In both these positions, the earth would bend sideways during midday orientation (facing sun). That is the Nose will have to neither look up nor look down. Sun will be at level.

Exercise 7.3 Seasons and earth's tilt

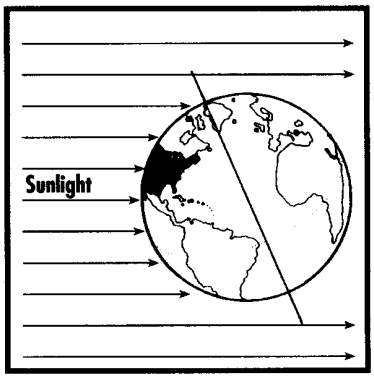


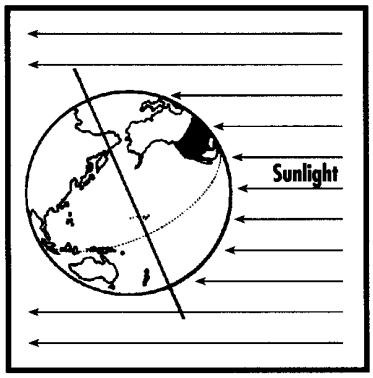
For this exercise chose four children to play the role of Earth. Position them at June, December, March and September. Let them all bend such that they are aligned with the Polaris

Now observe them. See how they are all tilted. At one positions towards sun and opposite position away from. In between it is neither towards nor away but sideways. Ask: "So everyone is tilted toward Polaris, but is everyone leaning the same in relation to the Sun?"

Let the children imagine that the head is northern hemisphere. Discuss "Who has their upper body (Northern Hemisphere) leaning most directly toward the Sun?" Identify student with forward bend directly toward the Sun? "Who has their upper body leaning most away from the Sun?"Identify the student on the opposite side of the circle who is back bending away from the Sun.

The idea is to show that more direct the sunrays any area in the earth receives, the intensity of the light/ heat is much more and the result is summer. Conversely in the winter position, Sun's rays are slanting, falling on a large area (as shown by the activity ahead) resulting in lesser light and heat and therefore winter. It can be seen that the 'middle' position of March and September are not affected by the tilt and all the areas on earth receive direct sun rays.

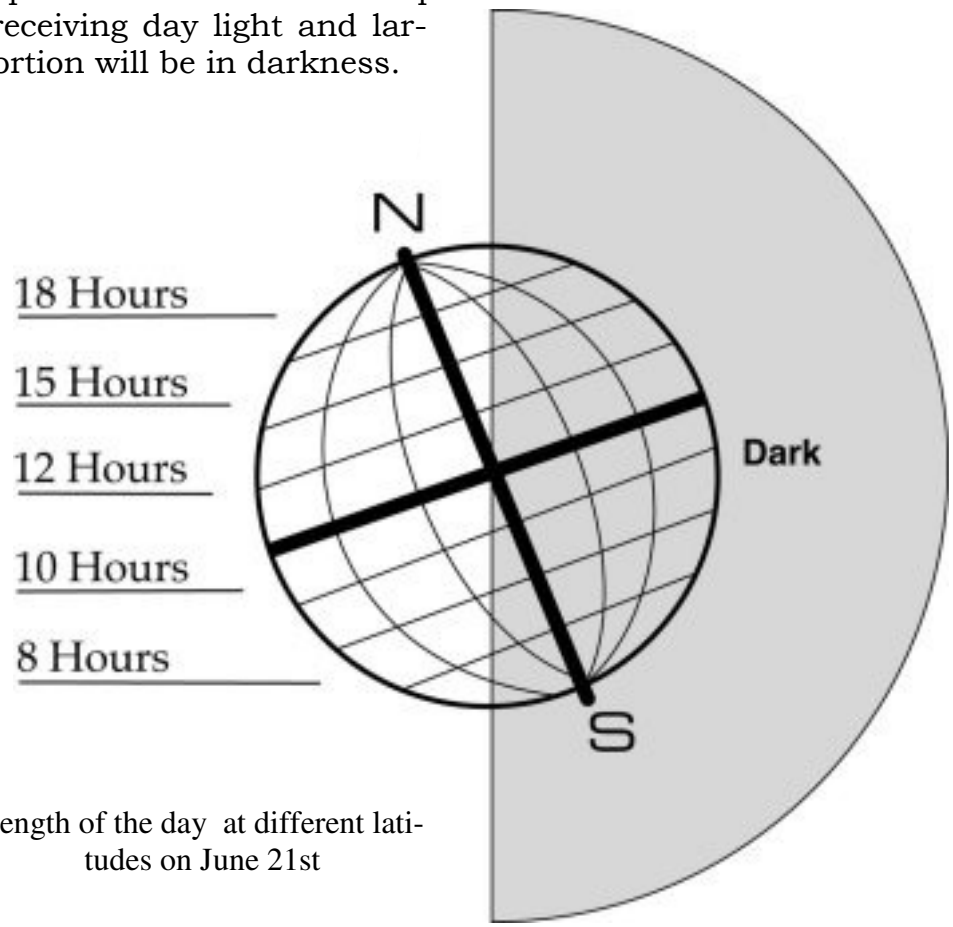




Exercise 7.4 When it is summer in northern hemisphere it is winter in southern hemisphere and vice versa

After doing the above exercise use a globe to demonstrate that in any given season whatever happens in the Northern hemisphere, the reverse happens in the southern hemisphere. Hence there is a reversal of seasons.

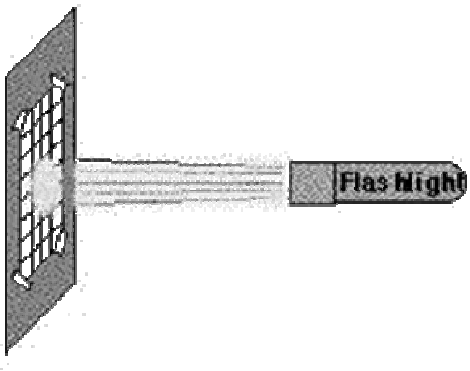
The tilted globe can be also used to show different lengths of the days in summer and winter. It will help that a large rubber band/ string is used to show the equator. Another rubber band/ string is used to demarcate the area receiving sunlight from the area in darkness. It can be seen that on a particular latitude circle in Northern Hemisphere larger portion is receiving sunlight and lesser portion is in darkness. That days are longer and nights are shorter. Whereas in winter, latitudes in Northern hemisphere will have a smaller portion receiving day light and larger portion will be in darkness.



Length of the day at different latitudes on June 21st

Exercise 7.5 Intensity of sun light :How Angle Spreads a Flashlight Beam

This activity is dramatic if done in a fairly darkened room.



For this activity we would need a graph paper clipped to a cardboard or a hard surface, clips that can hold the graph paper, flashlight (torch) and pencil.

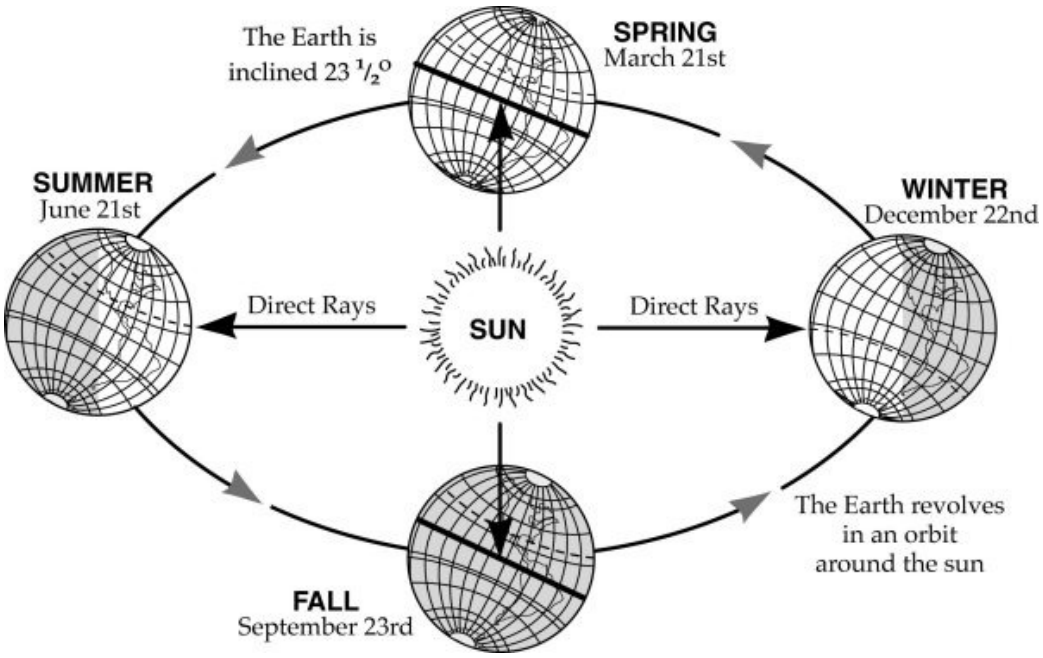
First, attach a sheet of graph paper to the cardboard with clips. Hold the board perpendicular to the floor and shine the flashlight directly onto the graph paper from the side, about two feet away. Be sure the flashlight is parallel to the floor, and, therefore, perpendicular to the paper. You might try placing the flashlight on a pile of books or some such improvised holder so that it does not shake. Trace the outline of the flashlight beam on the graph paper.

Now take away the graph paper. Attach a new one. Keeping the same distance from the paper to the flashlight, tilt the graph paper away from the flash light, say about 30 to 40 degrees. Trace the outline of the beam. Notice that one part of the beam is bright and other dim. The lower part of the beam will be bright while the top part will be bit dim. Mark out these areas. Keep this sheet also away.

Once again repeat the above step by placing a new graph paper, but this time tilting the graph paper towards the flash light. Trace the outline.

Is the spot always of same brightness? When is it brighter? Fainter? We can see that when the card is tilted away from the sun light the upper portion of the card is dim while bottom potion of card is brighter. The reverse is seen when we tilt it towards the flashlight.

Discuss with children, like flashlight the distance between Earth and sun does not vary and the amount of light is fairly constant. However in summer northern hemisphere is tilted towards the sun and hence the sunlight is direct and intense (sun is also seen high in the sky). Whereas during winter northern hemisphere is away from the sun and hence the sunlight is slanting and dim (sun is low in the sky) .The situation is exactly reverse in the southern hemisphere. It is due to this seasons like summer and winter result.



Seasons in Northern Hemisphere

NOTE: Many children wrongly believe that the tilt toward Polaris changes to cause the seasons. It is very important to use "tilt" specifically to describe a constant tilt toward Polaris. Learn to speak of different hemispheres as leaning or bending toward or away from the Sun. The hemispheres' orientation is what changes, not the tilt toward Polaris.

All India Peoples Science Network

The All India Peoples Science Network is a network of over forty Peoples Science organisations spread all over the country. The AIPSN started its activities as a network of activist organisations involved in Science Popularisation and in examining related to the interface of science with society. Since the pioneering efforts of the Bharat Jan Vigyan Jatha, in 1987, the AIPSN has emerged as a pioneer in activities related to science communication and popularisation.

The AIPSN, which had its initial thrust in the area of Science Communication, pioneered the efforts of adult literacy in the country in 1990. It nucleated the Bharat Gyan Vigyan Samiti, which went on to spearhead the Total Literacy Campaigns in Districts across the country in partnership with the Ministry of Human Resource Development (MHRD). The success of the literacy movements and the subsequent integration of several state level BGVS organisations in the AIPSN significantly increased the reach of the AIPSN to over half the Districts in the country. The literacy movements in the AIPSN have now built on the massive mobilisation achieved through the total literacy programmes, and include activities related to continuing education, school education, women's empowerment, credit co-operative movements, rural micro-enterprises, etc,

The third major area of intervention by the AIPSN has been in the area of economic scientific and technological self-reliance. The AIPSN was engaged in two major communication and mobilisation exercises called Hamara Desh (Our Country) and Desh Ko Jano Desh Ko Badlo (Know your country, Save your Country) in the nineties. The programmes focused on encouraging local area planning and resource mapping and carried the message of local capability building for self-reliance. In addition to such co-ordinated programmes, member organisations within the AIPSN have done studies, conducted campaigns and created awareness on sectors such as health, pharmaceuticals, power, telecommunications, peace and disarmament, broader issues of globalisation, intellectual property rights, issues related to the World Trade Organisation (WTO), etc. Several studies and publications on these issues have been brought out by AIPSN member organisations.

In the conduct of such campaigns the AIPSN uses diverse communication strategies using slide shows, video films, public meetings, street theatre, etc. The AIPSN has used the mobile street theatre form (Kala Jatha) very effectively in the course of its campaigns. Twenty years after its formation, the AIPSN has a significant presence in over half the districts in the country, spread across all major states.


THE UNIVERSE
YOURS TO DISCOVER
INTERNATIONAL YEAR OF
ASTRONOMY
2009